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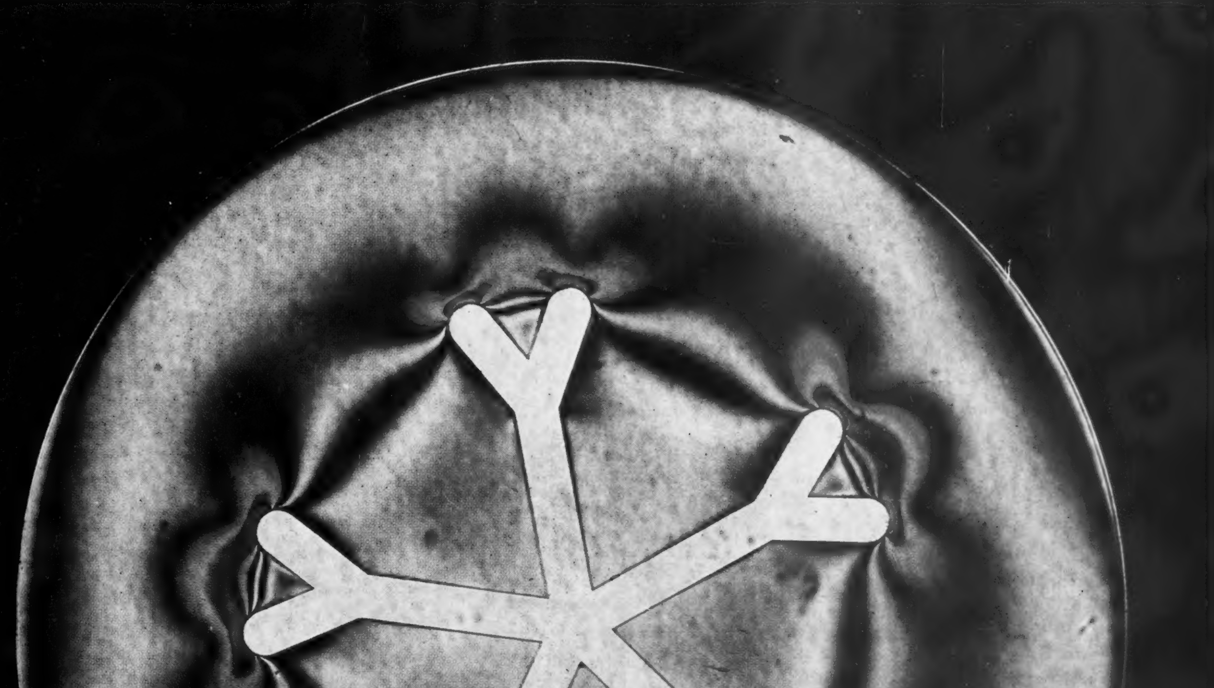
41

Astronautics

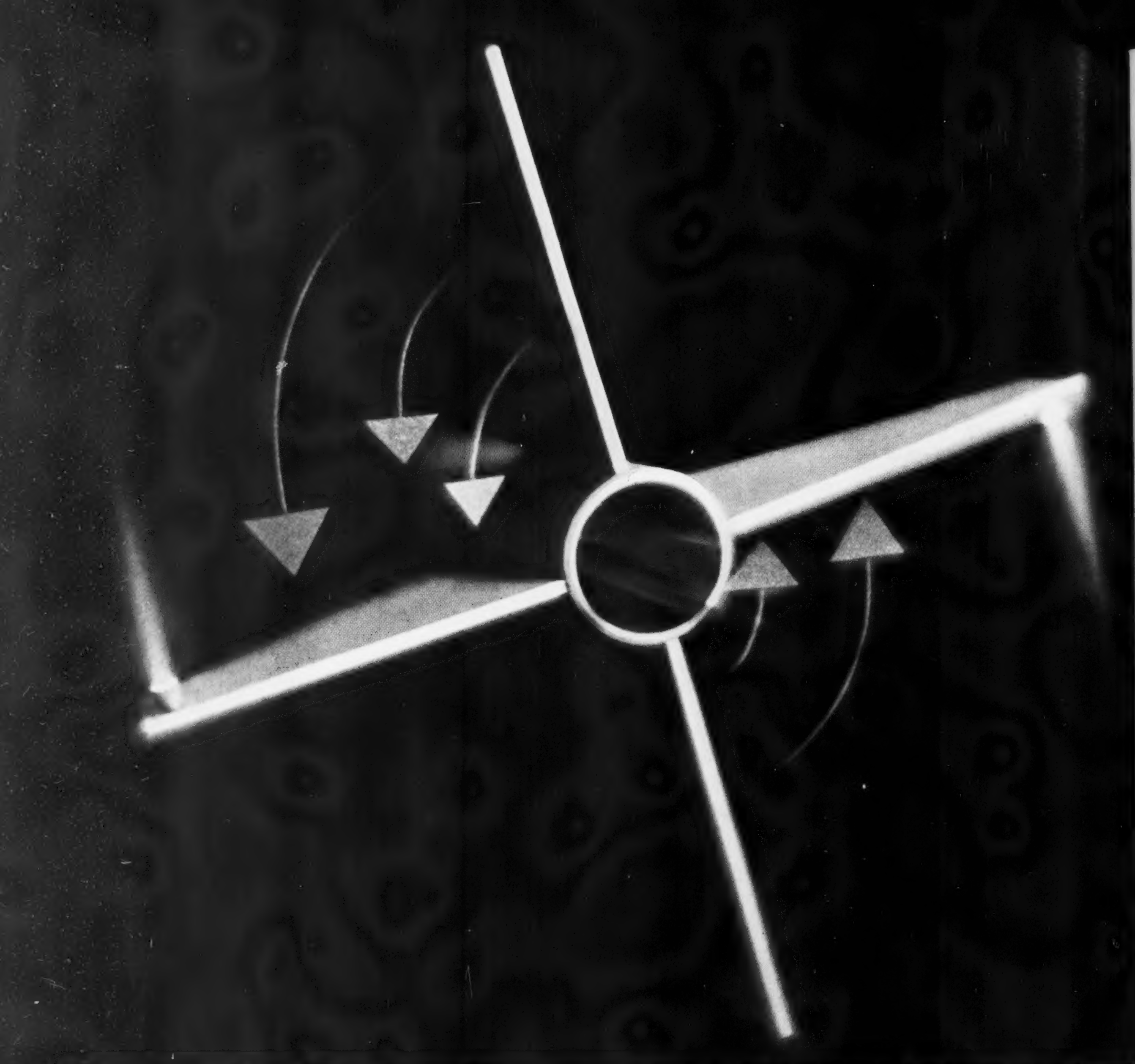
A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

DECEMBER 1960



Special Section on
GROUND SUPPORT AND OPERATIONS

Introduction to Astrobiology . . . . . . Hubertus Strughold
Snap 2—Nuclear Space Power System . . J. R. Wetch, et al.
A Satellite Motion Simulator . W. Haeussermann & H. Kennel



Reaction controls at work in space — symbolized.

STEERING GEAR FOR ASTRONAUTS

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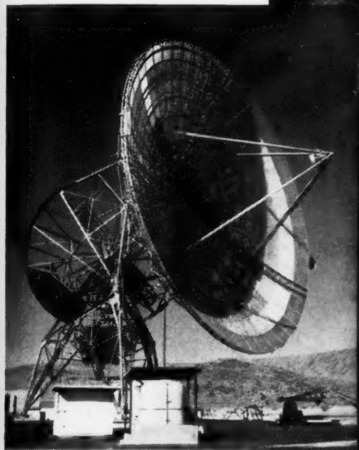

RECEPTION

The 85 foot parabolic antenna at Goldstone, California built in 1958 and used in tracking and recording telemetry from U.S. spacecraft.

TRANSMISSION

This 85 foot antenna, 7 miles from the reception facility, has recently been put in operation to transmit signals to U.S. spacecraft.

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The purely scientific data produced by such a facility ranges from propagation data and lunar reflectivity characteristics to the wideband data communicated to the station from the scientific instruments aboard the space probes. This is but one of the many space exploration activities pioneered by the Jet Propulsion Laboratory.

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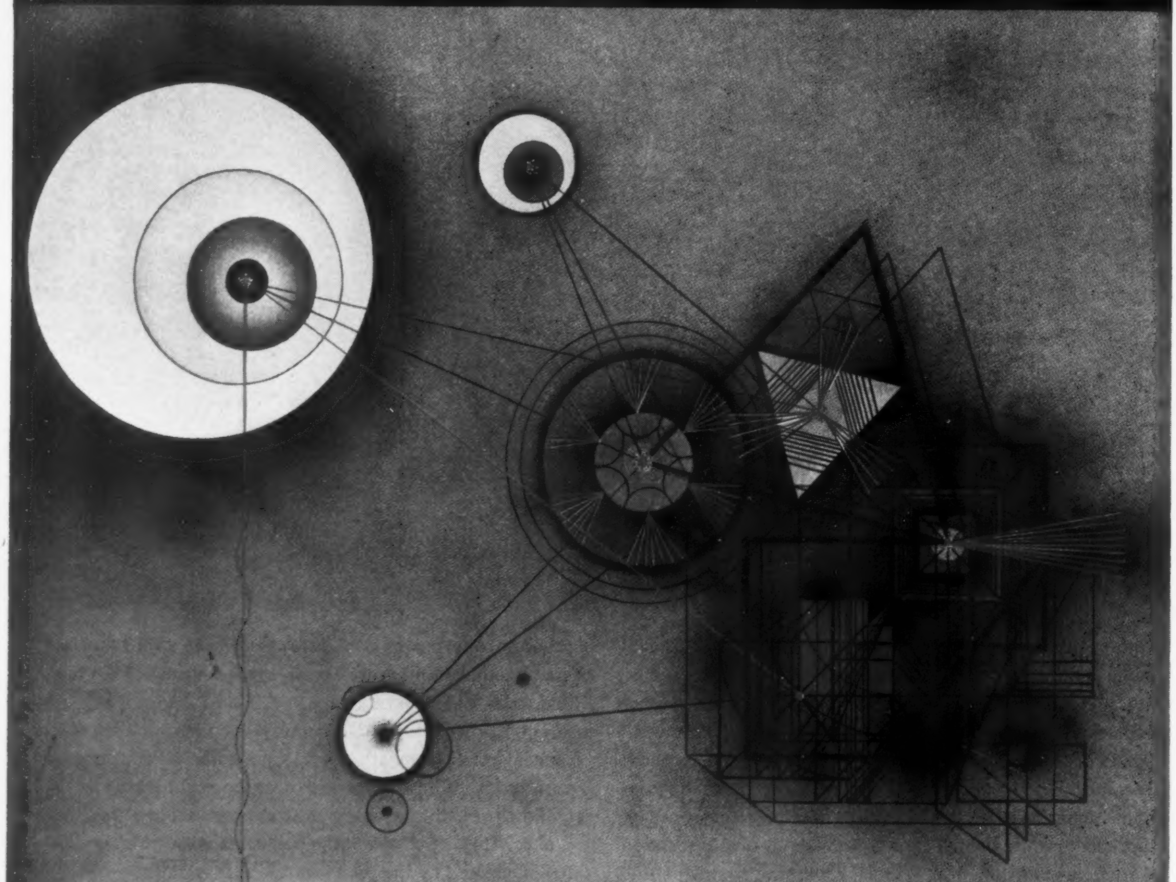

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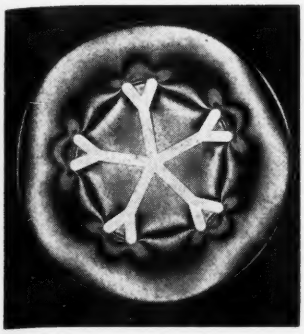

COVER: Photo by R. R. Parmerter shows patterns produced in photoelastic specimen of solid-rocket grain subjected to simulated internal pressure when in white-light polariscope. (ASTRONAUTICS cover plaques, 11 by 12 in., are available from ARS Headquarters at $2 each.)

Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY INC.

Vol. 5 No. 12 December 1960

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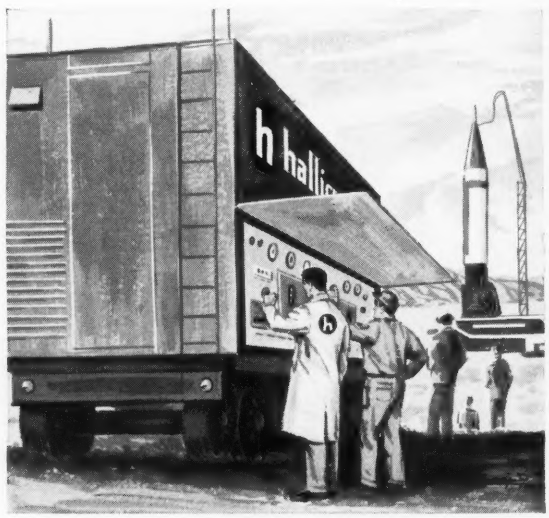

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Astro notes

MAN IN SPACE

• Project Mercury, the U.S. program to orbit an astronaut and return him safely, has slipped at least four months behind the ambitious schedule set by T. Keith Glennan last spring. In the 6-month period ended Sept. 30, Project Mercury was supposed to have completed six major flight tests—three with Atlas and three with Redstone. Only one took place, the abortive Atlas flight of July 29, in which the capsule was to be subjected to a maximum abort reentry test. Mercury officials chalk up the delays to the extreme complexity of the capsule's systems, and not to any particular bug or bottleneck. They are hopeful they can accelerate to the scheduled rate of flight testing soon, although they see no possibility of making up the lost time.

• Recent Mercury flight-test efforts, moreover, have encountered troubles. Bugs cropped up in the attitude-control system of the first Mercury-Redstone capsule at Cape Canaveral, necessitating a further delay in its maiden flight. And the last of the Little Joe series at Wallops Island failed when the Mercury capsule did not separate from the rocket booster. The whole assembly fell in 70 ft of water some 13 mi offshore. It was the second mishap in the Little Joe test series that would have killed an astronaut.

• NASA moved ahead on the Project Mercury follow-on program, Apollo, with the award of six-month study contracts to Martin, GE's MSVD, and Convair. The feasibility studies must define a manned space system capable of circumnavigating the moon with three astronauts aboard. They must also include a proposed plan for developing hardware, identify areas requiring long-leadtime research, and submit detailed cost estimates.

• AF will commence training Dynasoar pilots within the next year, according to Lt. Gen. Roscoe Wilson, Deputy Chief of Staff for Development. He also said the AF is interested in a one-stage winged manned vehicle capable of going from the earth into orbit and then returning under its own power. Such a vehicle would refrigerate to a liquid state oxygen scooped in at the upper levels of the atmosphere, thus augmenting its range. "The idea," said Wilson, "appears feasible."

• The Weather Bureau has established a Project Mercury weather support group at Suitland, Md., headed by Kenneth M. Nagler. The group will forecast winds, seas, cloud cover and visibility for all areas beneath the proposed orbit, with particular emphasis on the recovery zones in the central Atlantic. The group will also have units at Cape Canaveral and at the National Hurricane Center in Miami.

SPACE PROBES

• Sally, Amy, and Moe—three black mice—successfully flew 5000 mi down the Atlantic Missile Range aboard a highly instrumented Atlas nose cone. The mice reached an altitude of 650 mi, well within the lower Van Allen radiation belt. Equipment included a variety of film emulsions to record particle hits, a proton measuring device, and a closed-cycle hydrogen-oxygen fuel cell—all developed by GE. One experiment measured the rate at which human skin will absorb space radiation.

• Mid-December appears to be the likely time for the last of NASA's Atlas-Able moonshots. The goal is to place the 387-lb payload in a lunar orbit by firing the spacecraft's hydrazine rocket motor at the proper time. The U.S. has tried to orbit the moon five times—three with the Thor-Able and twice with the Atlas-Able. All the attempts have failed; in fact, none of the rockets ever attained escape velocity.

• Starting next year, NASA will set in motion its Ranger flight-testing program. The first five Rangers will use the Atlas-Agena B booster, which has more than double the lunar-payload capability of Atlas-Able. The first Ranger will be fired over a trajectory with an apogee of 620,000 mi, and the second will be fired into an orbit around the sun. Both will measure particles ranging in energy from as little as 5 ev up to 70-million ev. The remaining three Ranger vehicles will be used in attempts to land a small instrument package intact on the surface of the moon. The system will incorporate a 4-ft directional transmitting antenna giving its 15-w transmitter a communication range of 50 million mi.

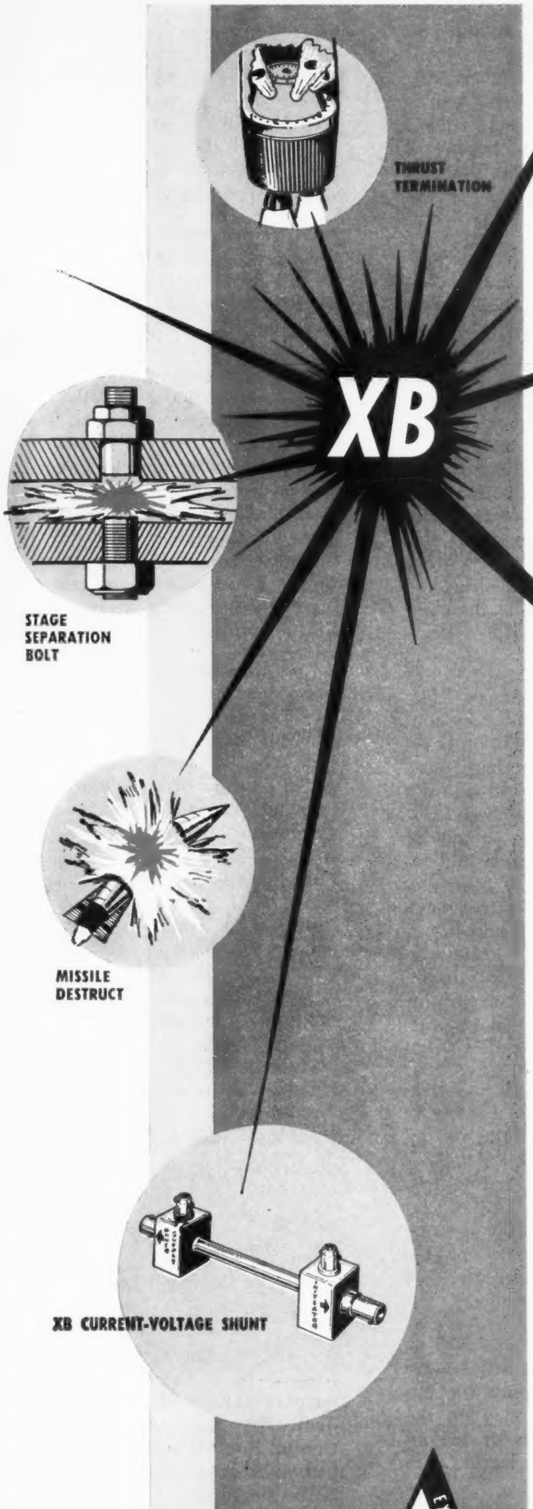
SATELLITES

• The Discoverer program produced its most successful shot November 12, the capsule from No. 17 in the series being ejected for the first time on command from the ground two days later (31 orbits) and caught in mid-air by a chase plane off Hawaii. The capsule carried human cells and plant life to be studied for effects of radiation.

• A Juno II booster orbited NASA's Explorer VIII early last month. The 90-lb "spinning top" package will provide direct measurements on the ionosphere, including electron concentration and temperature, ion concentration and mass distribution, and charge distribution on the surface of the satellite. Instrumentation includes single- and multiple-grid ion traps, a radio-frequency impedance probe, a Langmuir Probe, and an electric field meter operated on ground command. The satellite is powered by 32.3 lb of mercury batteries and has an estimated life of 2 to 3 months. Two payloads remain in the Juno II scientific satellite program: An ionosphere beacon to perform indirect radio measurements of the ionosphere and a gamma ray telescope. The beacon is scheduled for a December launch.

• NASA's four-stage Scout solid-propellant rocket is scheduled to attempt its first orbital flight in December. Payload will be a 12-ft inflatable sphere to gather air-density measurements at substantially lower altitudes than the 100-ft Echo. The Scout sphere is composed of two layers each of aluminum and mylar giving it rigidity after inflation.

• NASA Director T. Keith Glennan announced his agency will undertake an early demonstration of the technical feasibility of very light active-repeater communication satellites operating at 3000 to 5600 mi altitude. In addition, he said, NASA will support technically promising private proposals on a cost-reimbursable basis. The first of these may be a 150-lb active repeater which Bell Telephone Laboratories hopes to have ready for flight test within a year. ATT visualizes a system of 50 active repeater satellites operating at 3000-mi altitude to provide full-time global telephone service. Hughes



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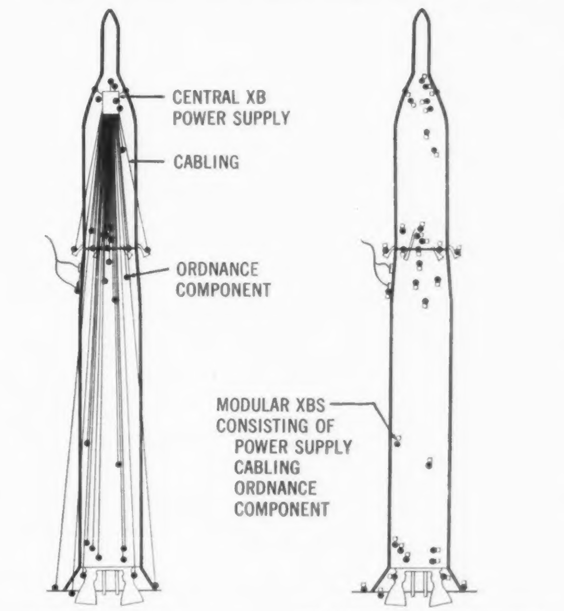

EXPLOSIVE ORDNANCE

McCormick Selph Associates

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also reportedly has a design ready for testing soon.

• NASA's second Tiros weather satellite was scheduled for a November launching aboard a Thor-Delta booster. It is to carry infrared sensors that were not available for the first Tiros. Weather experts say that Tiros I resuscitated the art of "nephanalysis"—weather forecasting based exclusively on cloud studies.

• The Navy's next Transit satellite, to be launched before year's end, will carry a better electronic clock than its two predecessors. It will be tracked by a new station in Alaska to determine auroral effects on the satellite's radio signal.

• AF failed in its initial attempt to launch a Samos observation satellite when the Agena second-stage rocket failed to separate from the Atlas booster. The Samos together with the Agena stage would have weighed 4100 lb, somewhat smaller than an approximate weight of 5000 lb for the Midas warning satellite. Both objects measure 22 ft in length and 5 ft in diam.

• Major flaws were discovered in the design of the Discoverer capsule recovery system as a result of simulated-high-altitude tests conducted by the USAF Arnold Engineering Development Center. Brig. Gen. Homer Boushey, Arnold commander, disclosed that the capsule retrorockets failed repeatedly at simulated altitudes of more than 100,000 ft. In one test, the retrorocket blew away its nozzle; in others, the nozzle eroded through. Wind-tunnel tests also disclosed separation problems with the capsule heat shield, which must be ejected cleanly after re-entry in order to deploy the parachute. Gen. Boushey declared that Arnold's facilities can gather in three or four nights' work the same information which would require many months of flight testing and ten's of millions of dollars.

• Explorer VII, launched in October 1959, stubbornly refuses to go off the air. It is equipped with a Bulova Watch Co. timer that was supposed to switch off the satellite after one year. NASA officials now believe the satellite will transmit for another year before there will be another opportunity for the timer to operate.

• Under a contract issued by the Army Signal Corps last month, Bendix Systems Div. will be responsible for design of Project Advent's satellite repeater, special ground equipment, checkout unit, and systems engineering under the technical direction of General W. M. Thames, commander of the Army's newly established Project Advent Management Agency. Bendix is also working on the preliminary design of shipboard terminals for the Advent system.

• The combination of the Post Office Dept.'s new electronic speedmail system and transmittal of facsimile letters by satellite bounce, both of which were demonstrated in November, boosts plans for a transoceanic "Orbital Post Office" (see August 1959 *Astronautics*, page 38) to the active contracting level along with plans for a worldwide network of communication satellites. ITT, RCA, ATT, Philco, and other concerns active in this area cite the need of extraordinarily reliable and long-lived electronic equipment for satellites as the chief hurdle to the realization of commercial systems.

• James Fletcher of Space Electronics Corp., a company now controlled by Aerojet-General, proposes a less ambitious but perhaps more quickly developable worldwide use of satellites—Sarus,a search and rescue system employing miniature radio transmitters which would radiate a few milliwatts of power on an international distress frequency in the UHF region to a network of several active-repeater satellites. These would transmit to ground stations any signals received plus a time code that would allow locating the distress-signal sender within a half-mile.

• Contributing to much discussion of communication satellites during an exciting month, Philco Corp.'s President James M. Skinner Jr. called for adoption of United Nations' control of international space communications to prevent misconstructions on the purposes and uses of communication satellites. "It seems almost essential," said Mr. Skinner, "that these satellites be under control of some world body to avoid the opportunity for unscrupulous people to play on the fears and superstitions of less-informed peoples of the world."

SPACE PROPULSION

• In a surprising policy switch, NASA and the AEC have decided to seek an industrial contractor immediately for the Rover nuclear-rocket program. This is the course which AEC and especially the Joint Atomic Energy Committee have urged, but it was resisted by NASA on the ground it would be premature to select a development contractor so early in the Rover program. NASA wanted to defer selection until the end of 1961, after the Kiwi-B test reactors operated with cryogenic hydrogen.

• "After we set up the joint Nuclear Propulsion Office to manage Rover, we determined that we needed a lot more integration in the program," explained NPO Director Harold Finger. "It's really more efficient to get some contractor responsibility in the program." Dr. Finger said the Rover contractor will not be selected on the basis of an engine design at the present time, but he was not ready to disclose the basis for selection. The new approach to the Rover program cancels NASA's request in August for proposals on a six-month preliminary design study of the Rover engine.

• The Rover reactor test program has exceeded expectations up to now. Latest was a test run of Kiwi-A3 at the test site near Mercury, Nev. The reactor held together during its maximum performance run of 15 min without significant power losses. Next year, NASA and AEC will start static tests with the Kiwi-B series, which will lead to a complete "breadboard" engine including propellant tank, automatic controls, liquid hydrogen, regenerative cooling for the nozzle, and a reactor-powered turbopump to deliver the cold hydrogen. (The Kiwi-A series just ended used pressurized gaseous hydrogen to carry the reactor's heat through a water-cooled duct resembling a rocket nozzle.)

• Aerojet-General's Aetron Div. received the contract for architectural and engineering services for the Rover test cell in October.

• NASA's Marshall Space Flight Center has ordered six-month preliminary design studies on solid-propellant superboosters ranging from 1 to 7 million lb in gross weight. The studies will be conducted by Aerojet-General, Grand Central Rocket, and Thiokol Chemical at a total cost of $225,000. NASA's growing interest in very large solid boosters may herald a switch from a liquid to a solid version of the Nova booster concept. Agency officials, however, still see a requirement for the F-1 single-chamber engine of 1.5-million-lb thrust.

OPERATIONAL!

Just 46 months from scratch, the Navy arms its first Polaris missile submarine

he Navy's Fleet Ballistic Missile weapon system is now operational. Somewhere in the seas that cover three-urths of the earth the USS George Washington is on station, armed with 16 Polaris missiles. Thus ends race against time; thus begins a new hope for peace. Lockheed, prime contractor and missile system mana-r, hails Aerojet-General, General Electric, Westinghouse, and the thousands of associated contractors, rge and small, who helped bring the Polaris missile to operational status.

LOCKHEED

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• The Titan engines as used in Dynasoar will have pilot control as well as monitoring by ground stations and an automatic control system in the vehicle. Aerojet-General, developer and producer of the Titan engines, has begun making these changes as well as modifications that will allow ignition of the second stage before separation, a condition necessary for the vehicle's stability. The Titan propulsion system with these changes will boost Dynasoar to near orbital speeds in early flight tests. Later orbital flights will employ a booster as yet not selected.

• Explorer VIII marked the 10th time in the past three years that JPL-developed solid-rocket clusters have successfully delivered satellites or deep-space probes into orbit . . . A complex of five static-firing test bays has been completed by ITT Labs and the AF at Edwards AFB. The cells will handle liquid engines for space vehicles rated up to 100,000-lb thrust . . . The test stand for the F-1 engine's turbopump is nearing completion at Rocketdyne's Propulsion Field Lab . . . Aerojet and Space Electronics Corp. have received BMD contracts for producing more Able-Star propulsion units to be used in launching Transit and Courier satellites . . . Douglas Aircraft has formed Astropower Inc. as a subsidiary to conduct advanced research on all forms of rocket engines for space vehicles. The new corporation will be headed by Y. C. Lee, George Moe, and E. W. Smith.

SPACE SCIENCE

• The highlight of the science sessions at North American Aviation's IX Lunar and Planetary Exploration Colloquium, held Nov. 2 and 3 at NAA's Missile Div., was a summary report by A. Dollfus of the Paris Observatory on 700 calibrated photographs, hundreds of drawings made by visual observation, and many hundreds of polarimetric measurements made of Mars during the last three oppositions of the planet. The data provided by Dr. Dollfus and his associates will undoubtedly receive wide and various interpretation. Their analyses have already led to one surprising conclusion on their part—that the Yellow Veils of Mars are composed of particles between 2 and 5 microns in diameter, which give a polarimetric curve somewhat like that of smoke. Sequential photos and drawings by these astronomers have apparently established high points on Mars associated with stable cloud formations, more and better-defined data on seasonal propagations of polar caps and dark areas, and some insight into the larger atmospheric currents on the planet. These studies, not previously reported on by Dollfus and his co-workers, should appear in the literature soon.

• The Colloquium also served to announce the availability of the first of two lunar atlases prepared by the AF cartography group under the technical direction of G. P. Kuiper of the Univ. of Arizona. The first, an "Orthographic Atlas of the Moon," for the scientists, charts 5000 base points combined with the best photos and grids available. The second will provide Cartesian coordinates for the engineers. These atlases will be priced at about six or seven dollars apiece.

• As in previous of the Colloquiums, many prominent scientists spoke out for greater funding for astronomical observatories and staffs here on earth. Planetary studies in particular have lagged for lack of money and sustained support. The audience warmly supported such suggestions with applause. And the work of Dr. Dollfus documented the payoff that can be expected from long-term studies by professional astronomers.

• A Type-3 flare, the largest of solar explosions, occurred Nov. 13, giving North America a rare spectacle of the aurora borealis, and causing major disruption of global radio communications. A spokesman for the Enrico Fermi Institute of Science in Chicago said detection equipment reported a 50 per cent increase in cosmic-ray density associated with the flare. This is the third Type-3 flare this year. It will add to the topics of discussion for the important session on solar-terrestrial relationships on the first day of the ARS Annual Meeting this month.

• In this connection, quoting from No. 40 of the IGY Bulletin, which in part reports on NBS studies of the sun: "The lack of geomagnetic and ionospheric disturbances in the solar event of June 9, coupled with the other apparent anomalies, has forced a critical reappraisal of past techniques of observation and of earlier conclusions from observational data. The resulting inquiry can be expected to lead to better understanding of the relationships among individual components of associated solar events and a consequent improveemnt in radio-propagation prediction methods."

• William R. Sinton of the Smithsonian Astrophysical Observatory, who in 1958 observed the infrared reflection spectrum of Mars between 2 and 4 microns with the Palomar telescope, and found absorption dips at 3.43, 3.56, and 3.7 microns—the 3.43 point being associated with the carbon-hydrogen bond (see page 20)—makes further measurements this month with the Observatory's 200-in. instrument.

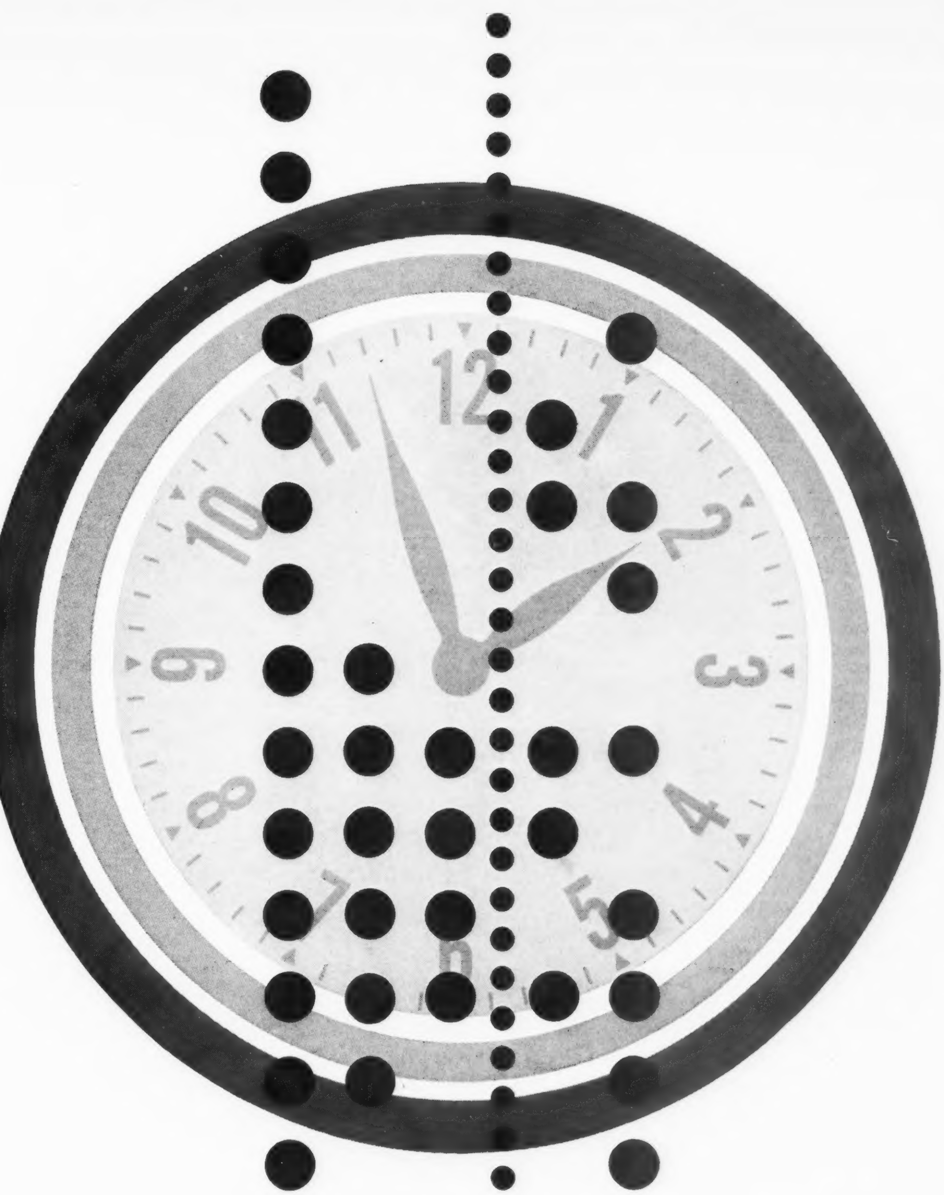
• Completion of the 600-ft-diam radio telescope at Sugar Grove, W.Va., has been set back in schedule to 1964 owing to unexpected engineering difficulties with the main antenna and its reflecting surface of aluminum mesh. Its cost estimate has jumped from $79 to $100 million.

WEAPONS

• Top Army Officials are conducting an informal study of the Nike-Zeus anti-ICBM missile with DOD and White House science advisers to see whether a speed-up should be ordered. A decision is expected this month. The Army is anxious to buy time on Zeus by starting some production now, although it has dropped its previous goal of an immediate design freeze and all-out production to equip 70 battalions. It cites significant technical progress during the past year, including doubled radar power and a new third-stage rocket motor, to support a limited production order.

• The Nike-Zeus testing schedule calls for the start of interception attempts from Kwajalein by the end of 1961. Targets will be Atlas ICBM's fired from Vandenberg AFB, Calif., by the AF. The targets will be elaborately decoyed to see whether the Zeus radar-computer system can pick out the real warhead from a group of decoys. The decoy threat is a chief technical obstacle facing Nike-Zeus.

• The Pentagon okayed a $155 million boost in the B-70 bomber development program for fiscal 1961. The additional funds will provide for construction of one airframe for static tests, one XB-70 for flight tests, and two YB-70 prototype bombers. The program heretofore was limited to construction of two XB-70's without weapons capability. The action brings to $265 million the amount obligated to the B-70 this fiscal year and the total obligations for the development to $797.3 million since it be-



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gan. The AF is seeking about $400 million for the program in fiscal 1962; it visualizes the total cost of the development at about $1.5 billion, including 9 to 12 prototype aircraft. Flight date for the first XB-70 remains December 1962, with the first YB-70 to fly a year later.

• The Navy successfully test-fired its first A-2 Polaris over a distance of 1600 st mi from Cape Canaveral. The weapon has a design range of 1500 n mi (1725 statute) as compared with 1200 n mi (1380 statute) for the A-1 Polaris scheduled to become operational aboard the USS George Washington in mid-November. The A-2 Polaris has an Aerojet first-stage motor which is 30 in. longer than A-1, and it has a fiberglass-casing second-stage motor by Hercules Powder.

• AF is studying Ellsworth AFB, S.Dak., to determine its suitability as a support base for the Minuteman ICBM. If surveys and soil borings are successful, Ellsworth could become the second deployment area for Minuteman silos after Malmstrom AFB, Montana. Ellsworth is already scheduled to receive a squadron of nine Titan I missiles organized into complexes of three each.

BALLISTIC-MISSILE DEFENSE

• ARPA's Project Defender research program to find means to counter the threat of ballistic missiles will have the counsel of a special technical advisory group set up in cooperation with Stanford Research Institute, Lincoln Laboratories, Cornell Aeronautical Laboratory, and the Willow Run Laboratory of the Univ. of Michigan. Charles W. Cook, ARPA's chief of research for ballistic-missile defense, will chair the group.

• "The Soviet Union has everything necessary to paralyze U.S. military espionage both in the air and in outer space . . . Any attempt to use satellites for espionage is just as unlawful as attempts to use aircraft for similar purposes . . . The main purpose of space espionage is to increase the efficacy of a surprise attack, making it possible to knock out enemy missile bases at the very start and thereby avoiding a retaliatory blow . . . From the viewpoint of the security of a state, it makes absolutely no difference from what altitude espionage over its territory is conducted." These assertions appeared in a recent issue of the Soviet magazine "International Affairs" in an article by G. Zhukov discussing ballistic-missile defense and the U.S. reconnaissance-satellite program.

GSO, GSE

• Ground operations and support continue to be areas of major concern for both the military services and NASA (see page 34). The AF last month announced another major study contract on future GSO and GSE — this one with Motorola Military Electronics Div. and the Douglas Missile and Space Systems Engineering Dept., known as Study Requirement 17530, "Design Criteria for Automatic Test and Checkout Systems," with these objectives:

1. Validate the operational and maintenance requirements for test and checkout across the spectrum of future AF weapon systems through 1975.
2. Insure compatibility of design criteria for future weapon systems and test and checkout equipment.
3. Determine feasibility of standardizing equipment and procedures.
4. Determine feasibility of designing integrated multipurpose automatic test and checkout systems.

The first part of this study will involve a survey of representative existing weapon systems and associated test and checkout equipment.

• The oceangoing barge for hauling the Saturn booster (see page 30) was completed last month.

• Central operational control of worldwide portable tracking stations for Transit satellites has been assigned to Headquarters of the Pacific Missile Range, Pt. Mugu, Calif. The seven sites for portable ranges selected thus far are Argentia, Newfoundland; Seattle, Wash.; Las Cruces, N.M.; Sao Jose Dos Campos, Brazil; South Point, Hawaii; Salisbury, Australia; and San Miguel in the Philippines. Each station will consist of two 5-ft antennas, two Doppler receivers, a time-signal receiver, and data-reduction equipment . . . A PMR computation center that will integrate tracking, prediction, and control tasks for missile and space-vehicle operations will be designed under Navy contract by Convair, with Electronic Associates doing work on high-speed computing equipment under subcontract.

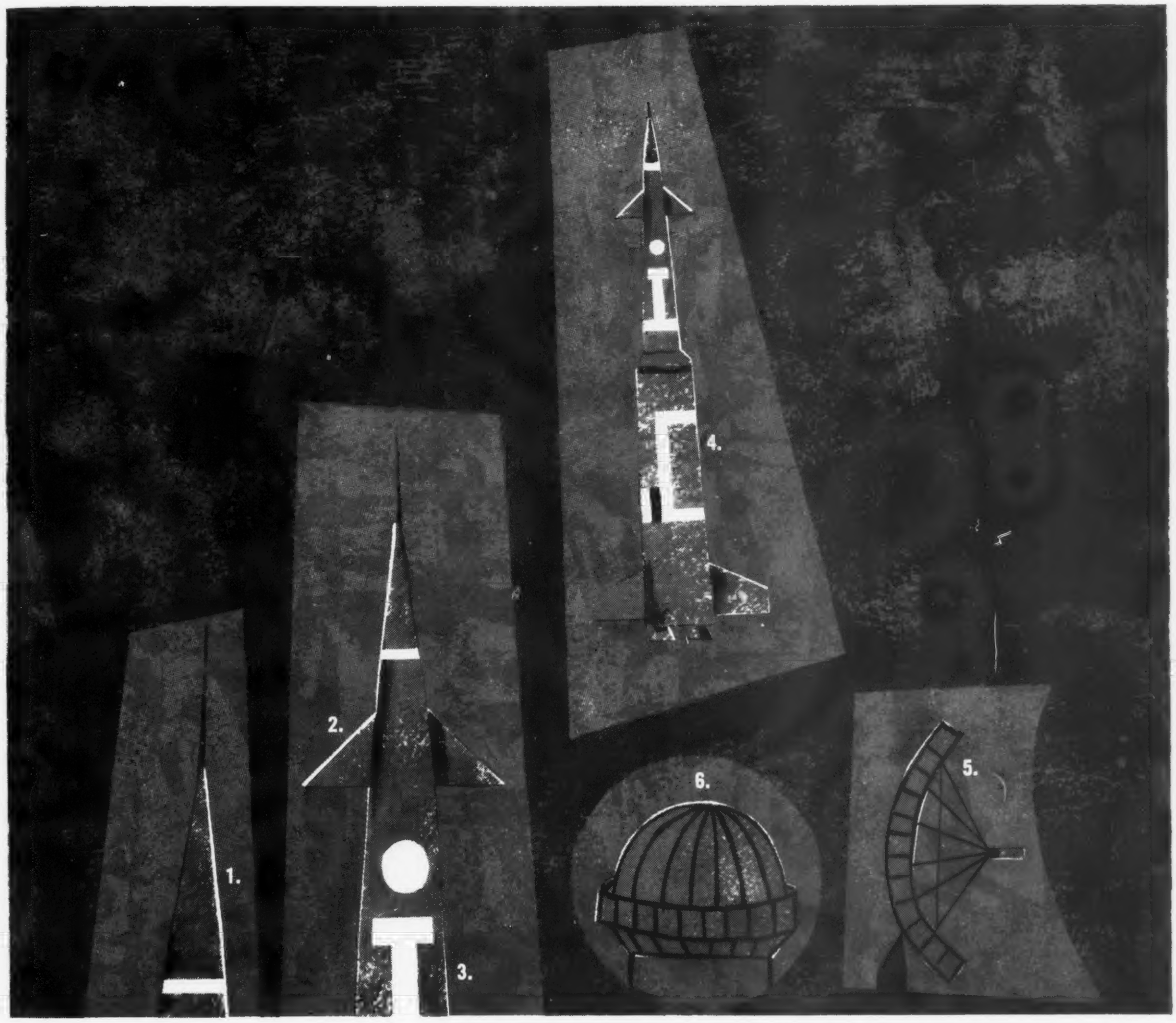
• The first comprehensive study of potential hazards in launching missiles, aside from radiological hazards, is claimed for work being done for PMR by the Aeronutronic Div. of Ford Motor Co. The study is expected to be of importance in the determination of suitable launching sites for coming super boosters.

ORGANIZATION

• A new push for Pentagon unification appears inevitable, but don't look for one service in one uniform. A committee headed by Sen. Stuart Symington (D., Mo.) will hand President-elect John F. Kennedy a set of recommendations for Pentagon reorganization by the end of December. This will doubtless call for important unification measures along lines urged by the AF and resisted by the Army and Navy, and their backers, on Congressional Hill. Washington observers believe the Symington group will urge elimination of the individual service secretaries and their assistants, and creation of a single Defense Chief of Staff in place of the cumbersome Joint Chiefs.

• What Congress will be willing to accept is a crucial factor in any move toward military unification. The House and Senate Armed Service committees have always resisted a single military staff because of alleged fears it would lead to military pre-eminence in American government. They will probably resist the concept of a single service even more strenuously. Most promising area for unification seems to be the civilian superstructure of the Army, Navy, and AF. The individual service secretaries may become Assistant Secretaries of Defense for their respective services, which would remain as administrative organizations. Also possible is a reorganization of the military combat and support forces into functional commands — strategic, mobile strike, continental defense, logistics, and research and development.

• In a reorganization move of its own, the Pentagon last month assigned the nation's radar space detection network (SPASUR) and the National Space Surveillance Control Center to the operational control of Gen. Laurence Kuter's Continental Air Defense Command, where it will become an adjunct of the Ballistic-Missile Early-Warning System. NSSCC will gradually withdraw from the business of supplying orbital information on known space vehicles, leaving this task to NASA. ♦♦



BRUNSWICK OFFERS COMPLETE CAPABILITY FOR AEROSPACE PROJECTS

"Complete capability" sums up Brunswick's ability to produce results at any stage of missile development. From in-house design and production to thorough testing, Brunswick brings to each new job a vast background in successful development of components and primary structures. **1. In nose cones and radomes,** Brunswick designs and materials can be tailored to meet rigorous new requirements for high temperature electrical and ablative purposes. **2. In wings and fins,** Brunswick engineering allows new plastic structures and antennas utilized in combination for more design freedom with maximum efficiency. **3. Missile bodies** constructed by the Strickland "B" fiber glass filament-winding process offer exceptional values in weight-strength ratios while meeting design requirements for unusual shapes and sizes. **4. Brunswick rocket motor cases** constructed by the Strickland "B" fiber glass filament-winding process consistently demonstrate superior properties, whether large or small. *Pressure vessels* designed by Brunswick can deliver an S/D ratio as high as 2,000,000. **5. Reflectors** of metal honeycomb or plastic construction are designed and manufactured to meet close tolerance and conform to the highest standards of quality and performance. **6. Ground radomes** are readily available for ground support applications. Constructed of solid laminate, honeycomb core, or foam, they are standard production design at Brunswick. From the starting line, or at any stage of the development race, Brunswick's complete capability is ready to make your ideas work faster and better. Call on Brunswick's ability to produce results. Brunswick Corporation, Defense Products Division, 1700 Messler Street, Muskegon, Michigan.

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For the record

The month's news in review

Oct. 4—Army launches 51-in.-diam Courier satellite, with some 20,000 solar cells on its exterior shell, into earth orbit.

—First flight test of NASA four-stage Scout rocket is "complete success."

—U.S. and U.S.S.R. agree on standards for judging space flight records.

—Navy claims new jet speed mark of 1390.21 mph was set by F4H-1 Phantom II on Sept. 25.

Oct. 11—AF fails in first attempt to launch Samos reconnaissance satellite into orbit.

—Advanced Atlas-E, 130-ton model, falls short of goal in maiden flight.

Oct. 12—NASA Chief T. Keith Glennan proposes that private industry be allowed to take over development of satellite communications systems, and that NASA offer to launch these systems at cost.

Oct. 13—Three "Mousketeers," Sally, Amy, and Moe, are recovered alive in miniature Project Mercury capsule, shot 650 mi into space by AF Atlas during 5000-mi trip.

—AF fires solid-fuel Phoenix missile to 200-mi altitude for radiation measurements.

—Explorer VII's preset alarm clock device fails to turn off satellite's radio transmitters.

Oct. 18—NASA successfully test-fires Iris rocket to 140-mi altitude.

Oct. 19—Kiwi-A No. 3 experimental nuclear rocket is run for 15 min at full power at AEC Jackass Flats facility.

Oct. 21—AT&T asks FCC approval to set up experimental space communications system across the Atlantic.

Oct. 24—AF successfully test-fires Titan 6100 mi for longest flight yet.

Oct. 25—NASA lets Project Apollo feasibility study contracts to Convair-Astronautics, GE-MSVD, and Martin Co.

Oct. 29—UK proposes joint space project with Western European countries and Commonwealth members.

Oct. 31—DOD does turnabout on B-70 policy, authorizes $155 million in extra funds for the current fiscal year.

International scene

By Andrew G. Haley

POLITICAL developments during the past five years in Latin America illustrate the need for foresight and statesmanship in all aspects of human and scientific relationships. A case in point involves the Fundaçao Santos Dumont of Brazil, and its Commission of Astronautics and Cybernetics. The Foundation is supported by the government of Brazil and has enjoyed the patronage of Air Marshal Luiz Netto dos Reys. Current President of the Foundation is José Ribeiro de Barros, while Flavio A. Pereira is President of the Commission of Astronautics and Cybernetics. The membership is composed of Brazilian scientists—many students of von Karman—and the level of scientific achievement is impressive, as is the enthusiasm for astronautics shown by the membership.

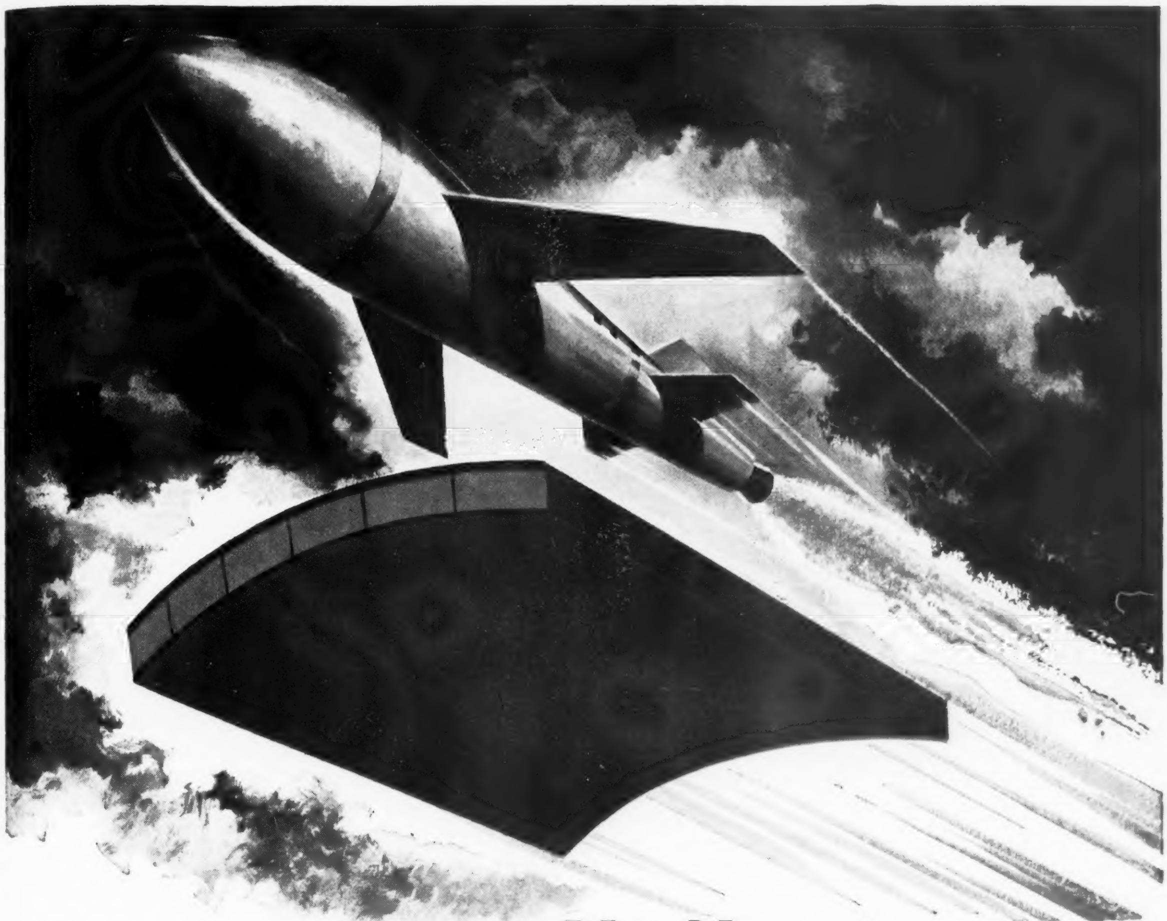
The Foundation has formally proposed a program of cooperation with the AMERICAN ROCKET SOCIETY looking toward the creation of an Inter-American Union of Astronautics [IAUU], the seat of which would be Sao Paulo, Brazil. The IAUU would be a forum which would undertake the organization of seminars and symposia and which would be sponsored by appropriate private societies, universities, governmental bodies, such as NASA and the Santos Dumont Foundation, etc. One of the first projects of the IAUU woud be to organize an international teaching faculty of inter-American experts in the appropriate fields of the natural and social sciences, who would be available for concentrated training courses of special value to industrial and research astronautics projects.

This proposal from the Foundation is deserving of the most serious attention of U.S. and Canadian astronautical societies. The suggested organization would directly implement U.S. Congressional inter-American programs authorized during the past Congress. Several American space scientists are going to Argentina this month to attend the Colloquium on Space Research which will be held in Buenos Aires Nov. 21–26 [*Astronautics*, August 1960, p. 80], thus providing an excellent opportunity to discuss organization of the IAUU with the appropriate officials of the Santos Dumont Foundation. A one- or two-day meeting could be held in Sao Paulo while the delegates are en route to Buenos Aires.

• • •

It seems quite probable that the 1962 Congress of the International Astronautical Federation will be held either in Sofia or Belgrade. Both cities are interesting and charming, and have excellent new hotel and convention facilities. Nicolas Boneff, Bulgarian delegate to the IAF, has been urging that Sofia be the site of the 1962 Con-

(CONTINUED ON PAGE 96)

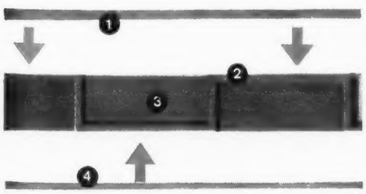


Johns-Manville Announces... **MIN-KLAD** INTERLOK

. . . a new structural system interlocking Min-K insulation and high-temperature reinforced plastic

Missile experience shows that in certain heat control situations no one material will perform as well as two (or more)—*an insulation with protective high-temperature facings.*

Problem is how to effectively combine these materials into a structurally strong unit? The answer is Min-Klad Interlok



1) Outer facing, **2)** Interlocking web, **3)** Core, any one of several Min-K formulations, and **4)** Inner facing.

All the above components combine to provide a custom-made structural strong insulating system.

—a new structural system that interlocks Min-K insulation and reinforced plastic, metal or other high-temperature facings.

The result: one product that gives the missile designer every advantage of high-temperature plastic or metal foil—strength, toughness, rigidity! Erosion resistance! High heat capacity!

. . . plus the outstanding advantages of Min-K insulation—an insulating core that has the lowest thermal conductivity available for service temperatures up to 2000°F steady-state, and higher for transients. Min-K's thermal conductivity is actually lower than the molecular conductivity of still air.

Wide range of facings

For the hot face, the missile designer can specify Min-Klad Interlok in a wide variety of heat-resistant and/or ablating materials—asbestos-phenolic (ARP-40), and similar reinforced plastics, as well as stainless steel and other heat-resistant metal foils and meshes. For some requirements, the cool face can be made of a different material—for example, one that offers characteristics required for bonding or fastening to other surfaces and parts.

Like all J-M Aviation insulations, Min-Klad Interlok is factory-fabricated to your specifications into external skin panels, heat shields, cylindrical liners or component housings of any shape or size. Write today for technical specifications. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

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Mail bag

Tiros I Expostulation and Reply

Dear Editor:

Although there may be underlying factors not mentioned in Mr. Osgood's article, "Structural Design of Tiros I," June *Astronautics*, there is no apparent reason for not using magnesium as the fabricating material. The use of adhesive bonding coupled with less rivets would have led to better structural damping and lower weight. It has been found in most cases that the theoretical advantage of aluminum over magnesium in heat transfer is largely hypothetical and is seldom realized in practice. This is especially true when the material is coupled with conversion coatings and surface finishes. The loading conditions of acceleration and deceleration would be especially important in the choice of magnesium which has an obvious stiffness to weight ratio advantage. The use of HM21A-H24 or HK31A-H24 sheet and HM31A extrusions would seem suitable for the structure described.

If the 25 per cent of the allowed 270 lb was used for the structure, the resultant weight was 67.5 lb. If this support unit had been entirely magnesium, the weight would have been less than 50 lb. As a matter of fact a structural allowance of 25 per cent of the total weight would seem to indicate a rather inefficient structure although there may be considerations which have not been stated. From what we understand about payloads a realistic saving of 15 lb would be even more worthwhile than on an aircraft.

Hemenway R. Bullock
Sr. Mechanical Engineer;
Raymond A. Hagstrom
Metallurgist; and
Robert A. Munroe
Material Analysis Specialist
Raytheon Company
Metals & Structure Laboratory

The prime consideration in the design approach for Tiros I was stiffness. The close tolerance (7') on parallelism of camera axes after launch and the rather extreme brittleness of the silicon solar cells tended to preclude a highly efficient structure weightwise. Reliability in terms of protection of components from excessive vibration during launch, accomplished by designing for a specific natural frequency well separated from the forcing frequency, also prevented a truly minimum weight design. Thermally, repeated experiments had shown, after due analysis, that the materials and finishes as finally chosen, would provide the required temperature control.

The structural and thermal characteristics of certain succeeding vehicles of the Tiros group are identical with Tiros I, whose well documented performance appears to justify the design approach.

Carl Osgood
RCA Astro-Electronic Products Div.
Princeton, N. J.

Kudos for ASTRO Covers

At the American Rocket Society Convention in Los Angeles, I was very impressed with a series of art abstractions that were displayed at your membership desk.

It is my understanding that these abstractions have appeared as covers on your publication *Astronautics*. Because these would make an outstanding exhibit in the Air Force Museum, in conjunction with our art program, I wonder if a set of these prints could be made available to the museum for exhibit.

Last year over 338,000 persons visited the museum and our attendance is ahead this year. Therefore, I can assure you that a display of these abstractions would receive much attention.

William Jay Ratsch Jr.
Chief, Office of Information
Department of The Air Force
Washington, D. C.

Illusion vs. Hallucination

The Astro Notes of the July 1960 issue of *Astronautics* contains a reference to the 15-day confinement studies conducted at Lockheed's Georgia Div. for ARDC (specifically for the Aerospace Medical Div. of the Wright Air Development Div.) under the supervision of Dr. O. S. Adams (Lockheed) and myself. The last sentence of the note reads as follows: "There is a report, however, that participants in such experiments still continue to be plagued by upsetting hallucinations."

I think that you will agree that a reasonable interpretation (and I fear the one probably made by your customary reader) of this statement would be that the SAC crews in question were in fact "plagued by upsetting hallucinations." My purpose, in writing this letter, is to set the record straight. Contrary to the findings of other investigations, in our studies ranging from 8 hr of isolation to the subject 360 hr of confinement, we have had no reports of hallucinations, disturbing or otherwise, that could not be much better described as being illusions. To illustrate the kind of thing that has occurred, it is a very common occurrence for an individual to be able to "hear" voices, music etc., particularly if he has a set to do so, when listening to fairly intense levels of white noise. However, in this case there is a stimulus present; it is merely misinterpreted or distorted by the auditory mechanism, the individual's imagination or whatever your pleasure may be. In a matter of a very few minutes exposure, and a small amount of explanation, the average individual is not the least bit disturbed by this experience. (Of course, he may be annoyed by the high intensity sound.)

W. Dean Chiles
Chief, Environmental Stress Section
Training Psychology Branch
Behavioral Sciences Laboratory
Wright Air Development Div.
WPAFB, Ohio

Editor: *By "plagued" was meant "nuisance"; "illusion" certainly better fits the example cited; and we are pleased to have this by way of explanation.*

IMPORTANT NEW OPENINGS FOR CREATIVE ENGINEERS

The Martin Company, at Orlando, Florida — prime contractor for Pershing, Bullpup, Lacrosse, Missile Master and BIRDiE — has senior level openings on its Technical and Research Staff in the following technologies:

- **Operations Research** — including optimum decision and prediction methods for existing and proposed weapon systems.
- **Information Theory**—with emphasis on optimum coding and signaling techniques.
- **Digital Computers** — analysis and advanced research, including learning machines.
- **Electronic Systems** — conceptual evaluation of advanced weapons systems.
- **Inertial Guidance**—conceptual and analytic investigation of advanced systems using novel components.
- **Electronic Packaging** — utilizing thin film and micro-electronic technology.
- **Environments** — study of shock, vibration, acoustics, temperature, and natural environments.
- **Structures** — development of new concepts, materials, applications, and design criteria.
- **Human Factors** — analysis related to military and space applications.
- **Missile Propulsion** — liquid and solid rocket propulsion and air breathing systems.
- **Ground Support Equipment**—with emphasis on mobile missile systems.

If you are qualified for senior level work in this highly select staff, please send a brief resume to Mr. C. H. Lang, Director of Employment, The Martin Company, Orlando 21, Florida.

WORK IN THE CLIMATE OF ACHIEVEMENT

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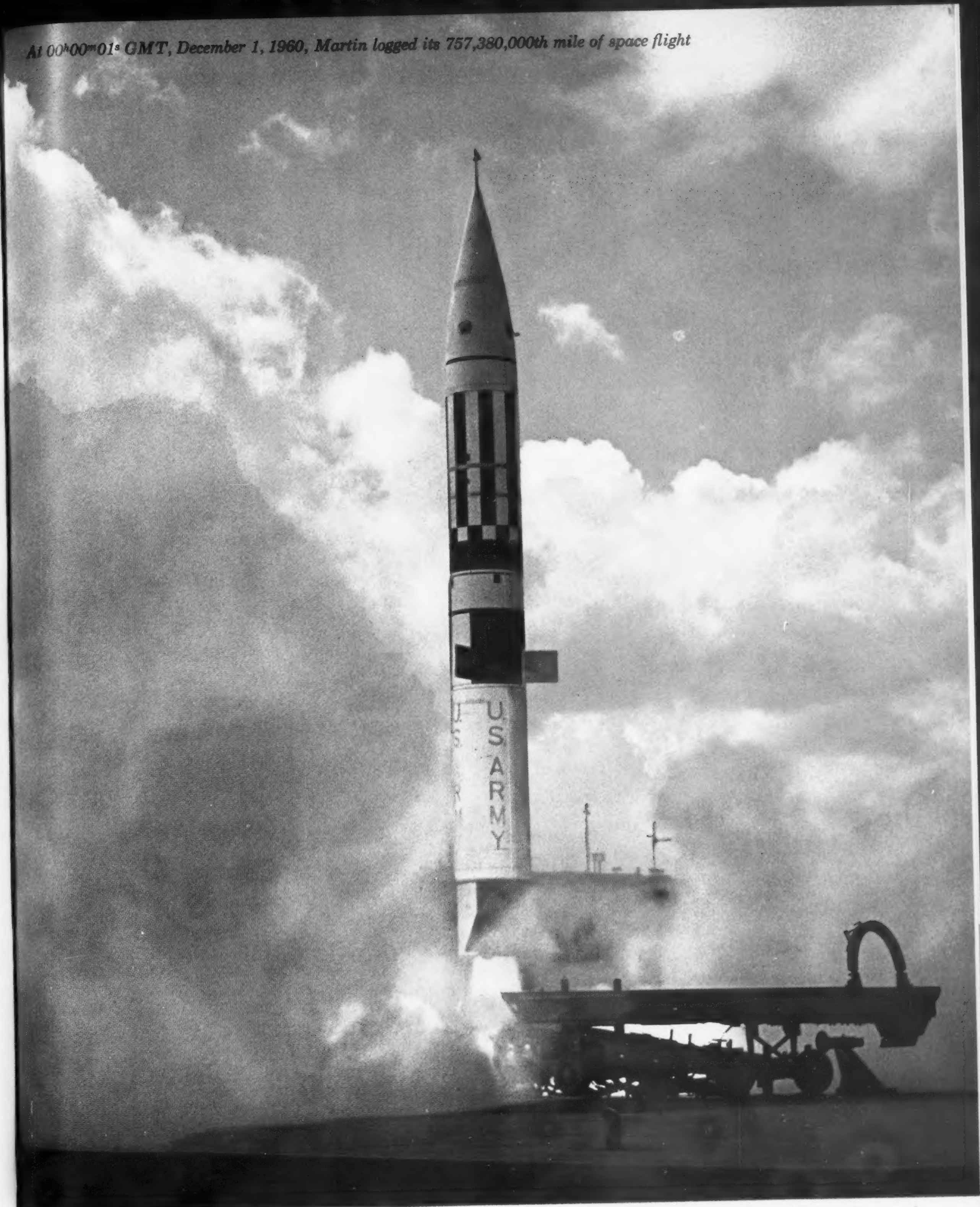

PERSHING—*in test at Cape Canaveral*

***Martin-built Pershing**—a major breakthrough for the Army in its program to develop the modern missile as a mobile field artillery weapon. Pershing moves over the roughest terrain on its own mobile launcher, is ready to fire within minutes.*

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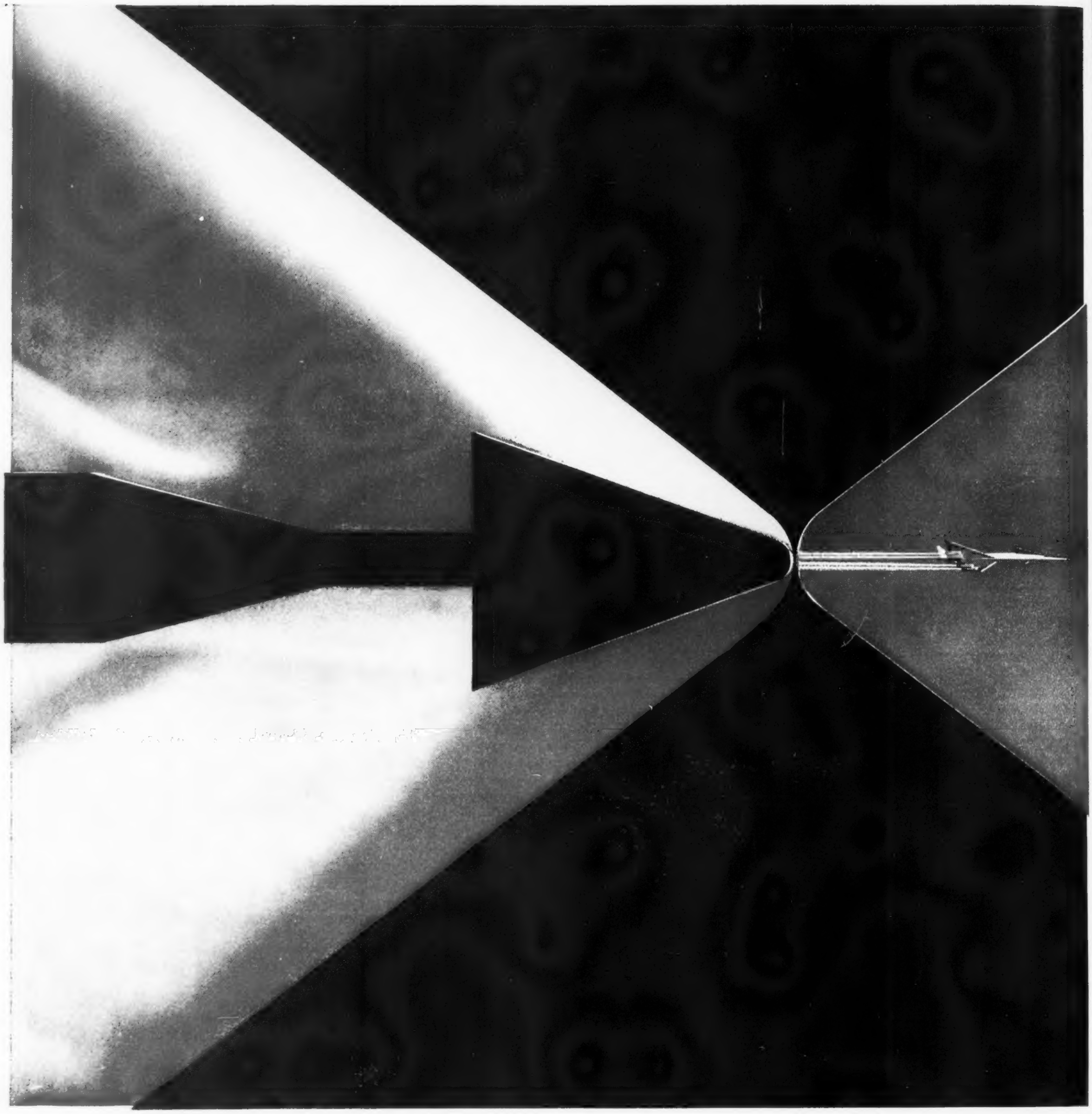

Portrait of a Mach number

Air blasting across an aerodynamic shape at Mach 2 (above, left) records its image on film. In private industry's most extensive complex of wind tunnel installations, Boeing engineers and scientists are defining the shape of the future in supersonic and hypersonic flight. A new hypersonic tunnel, the nation's largest privately owned facility of its kind, tests up to Mach 27.

Boeing's emphasis on research and development of future advances covers a wide variety of fields, including missiles, satellites, space vehicles, anti-submarine warfare systems, hydrofoils, commercial and military aircraft, gas turbine engines, electronics, communication, propulsion systems, vertical and short take-off and landing aircraft.

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Expansion of advanced projects and systems management programs of the future has created openings at Boeing for professional specialists in scientific and engineering disciplines, and other, non-technical, areas of company activity. You'll find at Boeing a professional environment conducive to deeply rewarding achievement. Drop a note, mentioning degrees and major, to Mr. John C. Sanders, Boeing Airplane Company, P. O. Box 3822-ARG, Seattle 24, Washington.

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Astronautics DECEMBER 1960

Hail and Farewell

THE YEAR 1960 was graced by the first fruits of the efforts of many of the ARS Technical Committees. Among these were the singularly successful conferences on Solid Propellant Rockets at Princeton, Space Power Systems at Santa Monica, and Electrostatic Propulsion at Monterey. Each of these will result in worthy proceedings volumes, part of a carefully integrated new ARS series under the very capable editorship of Martin Summerfield.

The year 1961 will be even more exciting, including among the ten or more national meetings a Missile and Space Vehicle Testing Conference at Los Angeles, a Solid Rockets Conference at Salt Lake City, a Guidance and Navigation Conference at Stanford, and a particularly significant meeting on Lifting Re-entry Vehicles at Palm Springs. The year will be climaxed by the ARS SPACE FLIGHT REPORT TO THE NATION in the New York Coliseum October 9–13.

The Society continues to grow in number of members, in services to members, and in professional stature. Its program has kept pace with the increasing sophistication of our national space and missile program, which now boasts second- and even third-generation versions of our military missiles and during 1960 placed a dozen satellites in orbit.

Major credit for maintaining an alert and imaginative Society should go to our permanent secretariat in New York, particularly Messrs. Harford, Hersey, and Hohl. The responsibility for sustaining the superlative quality for our conferences lies with the Technical Committee Chairmen, and by and large they have performed this duty admirably. Our elected officers have contributed their time and advice in far more than a minimal amount.

I wish to express to the membership of the Society my personal gratitude for a stimulating and rewarding year. We can all look forward to additional progress in 1961 under the leadership of a new Board of Directors.

Howard S. Seifert
PRESIDENT, AMERICAN ROCKET SOCIETY

An introduction to astrobiology

Examination of the chemistry, temperatures, and light conditions found in the atmospheres of other celestial bodies can provide clues to the origins of life and extend the study of biology to the cosmic spectrum

By Hubertus Strughold

AF AEROSPACE MEDICAL CENTER, BROOKS AFB, TEX.

Hubertus Strughold, now professor of space medicine and adviser for research at the Aeromedical Space Center, has been engaged in aviation and space medicine research for 35 years. Dr. Strughold delivered the first lectures on aviation medicine at the Univ. of Wuerzberg, Germany, in 1927, and from 1929 to 1935 did research and lectured on aviation medicine at the university. From 1935 until the end of WW II he was director of the Aeromedical Research Institute in Berlin, and in 1946 he was appointed director of the Physiological Institute of the Univ. of Heidelberg. Dr. Strughold came to this country in 1947 to join the staff of the then AF School of Aviation Medicine, and in 1949 was named head of the newly founded Space Medicine Dept. at the School. In 1951 he received the academic title of Professor of Aviation Medicine from the Air University and in 1958, after receiving the Theodor C. Lyster Award of the Aero Medical Assn. for his work in space medicine, was named the first Professor of Space Medicine by the Air University Command.

One of the new scientific fields fast developing in this Space Age is astrobiology. Biology is the science of life, as it is known to us, in all its forms, functions, and phenomena, and its environmental and biotic interrelations. Astrobiology extends biological thinking to other celestial bodies, such as the planets and their moons.

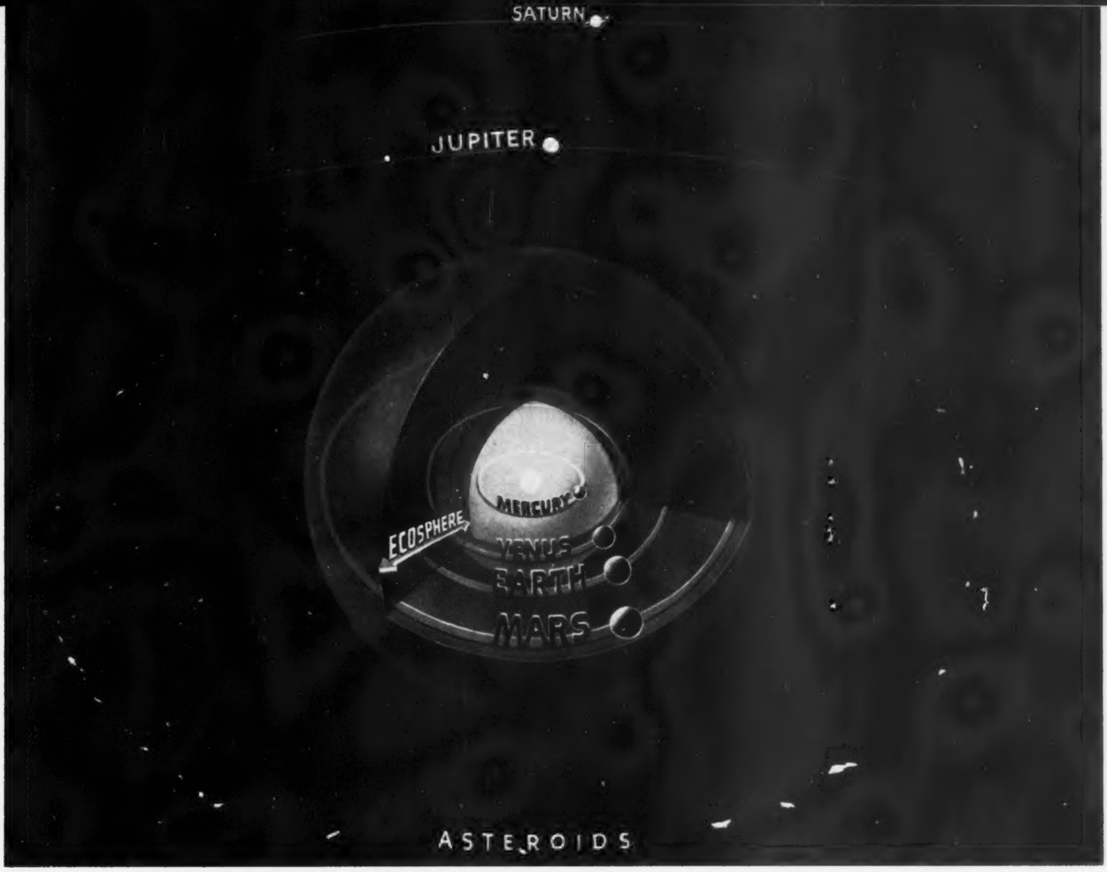
Since we do not know anything about creatures on other celestial bodies, the ecological aspect is now the only one on which astrobiological studies can be based. The terms astroecology and planetary ecology, therefore, are more accurate at present. But because ecology is a branch of biology and we soon may have knowledge of life on other celestial bodies, astrobiology is probably the more practical designation, especially since this term is generally better understood. Actually, it is already firmly established in literature.

The term astrobiology appeared for the first time as the title of a book written in 1953 by G. E. Tikhov, a Russian, and in the same year appeared in the text of a book by myself. Again, in 1957, it was the title of a book by F. Pereira of Brazil. Actually, this line of thinking was initiated in a report by G. Schiaparelli in 1887 about the "canali" of Mars, written almost a century ago. Since then, numerous publications concerning life on other planets have appeared, by such authors as P. Lowell, E. M. Antoniadi, E. W. Maunder, A. S. Jones, and others.

The rapid development of rocketry in the past 10 years has given a tremendous impetus to the study of the question of life on other worlds. Additionally, it has specifically posed the question as to what kind of environment an astronaut would find on the moon and the planets with regard to his own survival, i.e., from the standpoint of human physiology. Such space medical, or astromedical, questions will not be discussed in this article. We shall confine ourselves instead to the question of indigenous life on other celestial bodies—the proper topic of astrobiology.

What Chemistry for Extraterrestrial Life?

Astrobiological considerations can be based either on an assumption of the kind of life known to us, with carbon as the basic structural atom, or on an assumption of other forms and processes of life unknown to us and based on other elements, as for example, silicon. This extracarbonic biology, or we might call it parabiology, is beyond



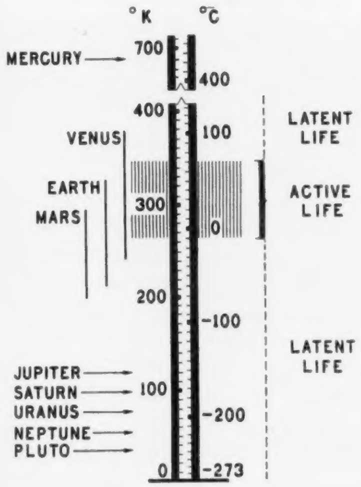
The Planetary System Ecosphere

the scope of this discussion.

Let us first consider the evolution of the earth's atmosphere as an astrobiological model. In the center of astrobiological studies are the planetary atmospheres and their chemistry, temperatures, and other properties.

The most interesting aspect here is that of the atmosphere's chemistry, especially if we include its historical evolution. This leads us into the field of *paleo-astrobiology*. Using the chemical development of the earth's atmosphere as an astrobiological model for a life-supporting planet, we can assume that the terrestrial primeval atmosphere, or *proto-atmosphere*, contained (CONTINUED ON PAGE 86)

Planetary Temperatures and Biological Temperature Ranges



Chemical Components of the Planetary Atmospheres

(After Hess, Kuiper, Urey, DeVaucouleurs and Whipple)

Planets	Solar Distance (In millions of km)	Most important atmospheric chemical components in order of abundance				
Pluto	5910	H_2	He	CH_4*	—	—
Neptune	4493	H_2	He	CH_4	NH_3*	H_2O*
Uranus	2872	H_2	He	CH_4	NH_3*	H_2O*
Saturn	1428	H_2	He	CH_4	NH_3	H_2O*
Jupiter	778.3	H_2	He	CH_4	NH_3	H_2O*
Belt of Asteroids	—	—	—	—	—	—
Mars	227.9	N_2	A	CO_2	H_2O ?	O_2 ?
Earth	149.6	N_2	O_2	H_2O	A	CO_2
Venus	108.2	N_2	CO_2	H_2O	O_2 ?	—
Mercury	57.9	—	—	—	—	—

* Probably in frozen state only

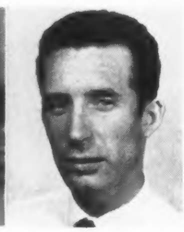
A satellite motion simulator

One of the year's important instrument developments, this simulator will be used to evaluate space-vehicle components

By Walter Haeussermann and Hans Kennel

NASA GEORGE C. MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.

Haeussermann



Kennel

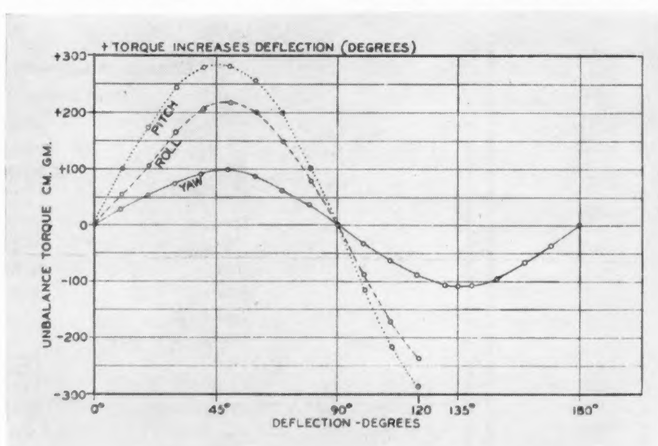
Walter Haeussermann is director of the MSFC Guidance and Control Div., responsible for guidance, control, navigation, instrumentation, and network systems for Saturn and future NASA space vehicles developed at Marshall. His background includes a doctorate in physics and mathematics from the Institute of Technology at Darmstadt, three years of work in guidance and control at Peenemunde, and research again at Darmstadt for the German Army and Navy. In 1948, Dr. Haeussermann joined Wernher von Braun's team and engaged in the development of guidance and control systems for ballistic missiles, becoming in 1954 director of ABMA's Guidance and Control Laboratory, and transferring to NASA in the same position in July 1960.

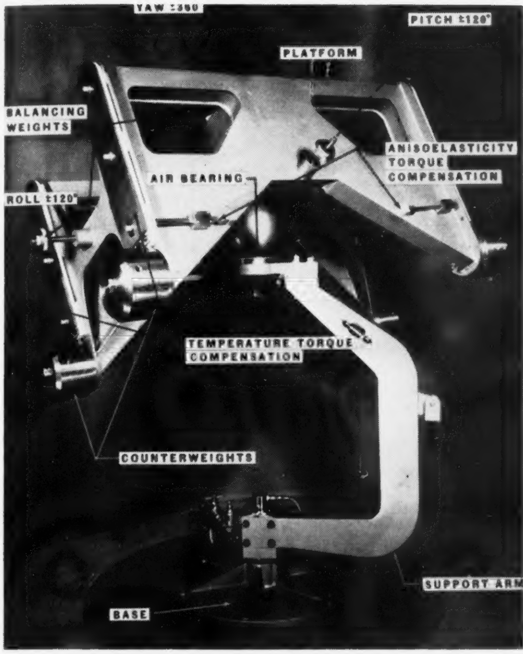
Hans F. Kennel received an M.S. in 1955 from the Institute of Technology at Darmstadt, Germany. After a brief association with Maschinenfabrik Augsburg-Nuernberg in Germany, he joined ABMA's Guidance and Control Laboratory in 1956, and transferred to MSFC's Guidance and Control Div. in July 1960. Chief of the control-systems feasibility studies unit of the Navigation Branch there, he is in charge of investigating space-vehicle control systems and work with the Satellite Motion Simulator.

LARGE moments of inertia, almost unrestricted angular freedom of motion in three axes, frictionless suspension and neutral equilibrium at any deflection angle—these are the requirements a simulator has to meet if it is to be used for development and checkout of satellite attitude-control systems. The Satellite Motion Simulator described in this article meets all the requirements as closely as present technology allows. It was developed in 1959 at the Army Ballistic Missile Agency, Huntsville, Ala., in a laboratory now part of the NASA Marshall Space Flight Center. The difficulties encountered during construction of the simulator, as well as their elimination, are also discussed.

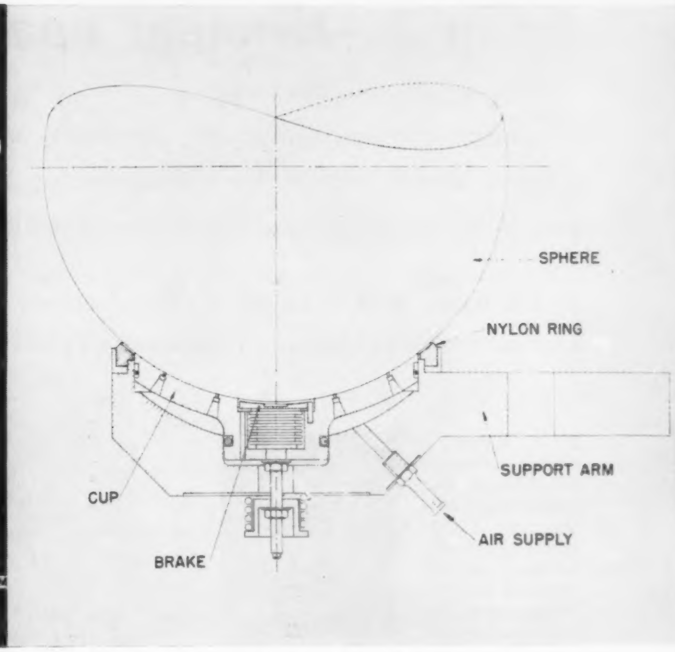
The name, "Satellite Motion Simulator," was chosen because the simulator provides angular freedom of motion in three axes (translational motions are not essential for the intended use). The behavior of attitude-control systems for one axis as well as for three axes can be studied. The most important usage, however, is investigation of coupling effects between the axes for large deflection angles. The movable part of the simulator is a platform which permits mounting of the control systems. The intended use of the simulator makes it necessary that, after the initial disturbance is imparted, the torques introduced from the outside into the system be negligible (these torques would be

UNBALANCED TORQUES BEFORE COMPENSATION





SATELLITE MOTION SIMULATOR



AIR BEARING

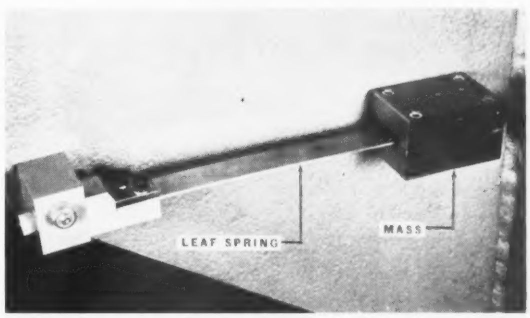
due to friction and unbalance). All the following requirements—set forth for the bearing, the platform, and the control components—are a direct outcome of the requirement to keep friction and unbalance to a minimum.

The need for negligible friction and large angular freedom necessarily led to a spherical air bearing as the only satisfactory solution for the support of the platform. Since it would be most difficult to simulate a vacuum, the platform encounters a small air resistance against angular motion; the angular velocities, however, are so small that this effect can be neglected. The simulator, however, is sensitive to air currents, therefore making an enclosure mandatory. The simulator has to be a completely self-contained system. All power has to come from within. Information can only be transmitted in or out by means of electric (light, radio) waves or the torque tolerance is exceeded.

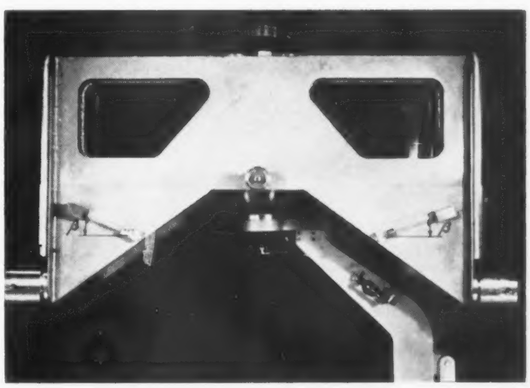
To keep unbalances to a minimum, the platform has to be antimagnetic, isoelastic, and insensitive to temperature changes. The term "isoelastic" is used here to indicate that the center of gravity of the platform (including mounted equipment) stays on the perpendicular through the center of rotation at any arbitrary deflection angle of the platform. The platform also has to provide ample room to mount the control systems plus associated equipment.

All these requirements, of course, cannot be fulfilled completely. In spite of the compensation devices discussed in a later (CONTINUED ON PAGE 90)

ANISOELASTICITY—TORQUE COMPENSATION



a. Device



b. Mounting

Snap 2—Nuclear space power system

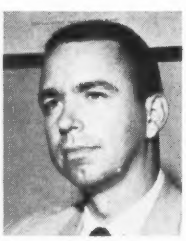
Proper integration of missions, payloads, and vehicles with nuclear power systems like the pioneering Snap 2 will both broaden and speed the exploration and exploitation of space

By J. R. Wetch, H. M. Dieckamp, and D. J. Cockeram

ATOMICS INTERNATIONAL, A DIV. OF NORTH AMERICAN AVIATION, INC., CANOGA PARK, CALIF.

J. R. Wetch is deputy director of Atomics International's Compact Power Systems Department, which is responsible for the development of the Snap reactor program for the AEC. After receiving a degree in chemical engineering from the Univ. of California in 1951, he joined North American as a research engineer, and headed the development of Snap 2 since its inception at AI, before he assumed his present position.

H. M. Dieckamp heads the Compact Power Systems' space power section. He joined AI upon receiving a degree in engineering physics from the Univ. of Illinois in 1950, and, after doing research on materials, became active in reactor development in 1955, since then having responsibility for developing the Snap-2 test facility and being project engineer for the Snap-2 Experimental Reactor.



D. J. Cockeram is head of Compact Power Systems' engineering development group, directing the developmental testing of compact nuclear power sources for space applications. He received a degree in E.E. from Oregon State, attended Oak Ridge School of Reactor Technology in 1953, and joined AI in 1954, where he has also served as head of the advanced systems analysis unit, studying compact reactors.

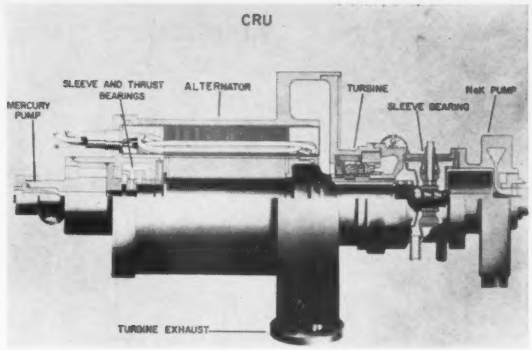
IN THE fall of 1957, the Atomic Energy Commission revealed the existence of the Snap-2 program, which was directed toward the production of a nuclear auxiliary power source for space application. The major details of this program were restricted by secrecy until Nov. 18, 1959. At that time, in an ARS meeting, the AEC announced the successful operation of a prototype Snap-2 reactor. Although many details of the program remained classified, it is now possible to discuss the system, its major characteristics, advantages, and information required by those who would incorporate the power supply into their vehicles.

Briefly, the system consists of a small, lightweight ($\sim$200 lb) reactor cooled by a 1200 F outlet sodium-potassium eutectic liquid metal (NaK) and a hermetically sealed mercury-vapor power-conversion system. The unique power-conversion system utilizes only one moving part, the combined shaft unit. It is suspended upon liquid-mercury bearings and contains the NaK pump, the mercury pump, the mercury turbine, and the alternator. The total system includes a mercury boiler, a direct-condensing heat-rejection radiator, and miscellaneous controls, supports and shielding. The complete system will weigh approximately 600 lb unshielded and will be capable of producing 3 kw of electrical power for nominally one year, unattended, in a space environment.

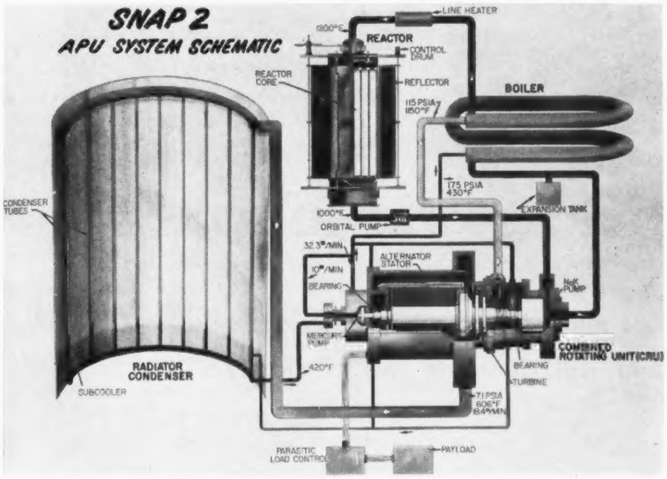
Following Atomics International's (AI) operation of the prototype space reactor in the Santa Susana field laboratory near Los Angeles, the power-conversion subcontractor, Thompson Ramo Wooldridge (TRW), successfully operated a prototype combined shaft unit at their development laboratories in Cleveland, Ohio. Thus, feasibility of all major components has now been demonstrated. Further engineering development, system testing, and vehicle integration are in progress.

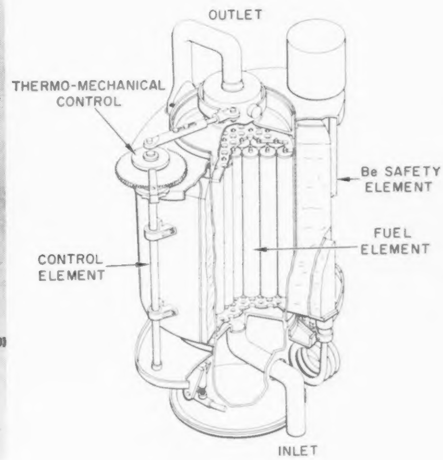
Let us turn for a moment to the inception of the Snap-2 program. The basic objective of the Snap program is to develop the technology and systems necessary to provide long-lived nuclear power for use in military and scientific satellites and space exploration. The specific objective of the Snap-2 program is to develop, test, and qualify a 3-kw nuclear auxiliary power unit (NAPU) for space utilization. The over-all Snap-2 development effort is directed toward the following general objectives:

1. Unattended, atomatic, maintenance-free operation
2. Maximum reliability
3. Maximum ruggedness



THE SNAP-2 SYSTEM: Above, left, the experimental reactor installed for a test and, right, a cutaway drawing of the Combined Rotating Unit. Below, left, the system schematic and a cutaway view of the reactor.





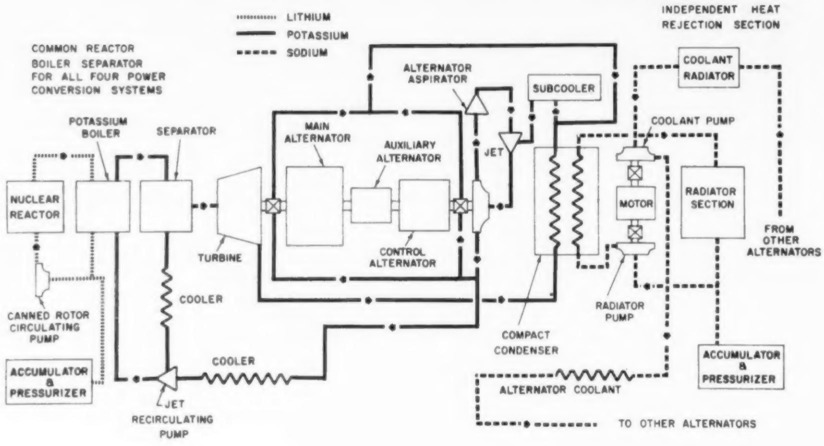
4. Maximum lifetime
5. Minimum size and weight
6. Maximum safety
7. Maximum ease of handling and of production
8. Maximum economy

The results of the 1956 preliminary design study, which evaluated the "state of the art" of reactor and power-conversion technology, as well as projected space-vehicle and mission requirements, established the following specific development objectives for Snap 2.

1. 3 kw net output
2. One year unattended automatic operation
3. System weight less than 600 lb
4. Cycle heat rejection area less than 110 ft^2
5. Operation in high vacuum
6. Operation at high temperature to provide for efficient radiative heat rejection
7. Operation under zero-g
8. Operation in presence of space radiations and micrometeorites
9. Remote startup in orbit
10. Re-entry burnup of systems which may operate in low-altitude re-entering orbits
11. Capability of withstanding the severe shocks, vibrations, gravity pressure, and temperature transients during vehicle launch
12. Capability of operating without subjecting the vehicle to excessive disturbing torques
13. Design and installation to permit efficient, low-weight shadow shielding of payloads
14. Packaging and installation to permit prelaunch startup and checkout with maximum safety and minimum vehicle and facility risk
15. Packaging and installing to provide for vehicle structural flight stability

The need for a long-life nuclear space auxiliary power unit (NAPU) grew out of the old USAF Project 1115, "Pied Piper." As a result of this project, a series of reports on a nuclear heat source for Project "Feedback" were issued in February 1954. Nuclear auxiliary powerplant proposals were made in October 1955. An AEC-AF study contract was let in May 1956. In January 1957, a feasibility report was issued which outlined essentially the system and cycle which are now under development. The AEC, through the Aircraft Reactors Missile Projects Branch of the Div. of Reactor Development, let the system development contract to Atomics International $3^1/_2$ years ago, in April 1957. A power conversion subsystem development subcontract was awarded to Thompson (CONTINUED ON PAGE 38)

ONE OF FOUR 250 KW ROTATING MACHINERY PACKAGES



Megawatt electrical power in space

Large space vehicles may require as much as several megawatts of electrical power . . . What system will generate this efficiently?

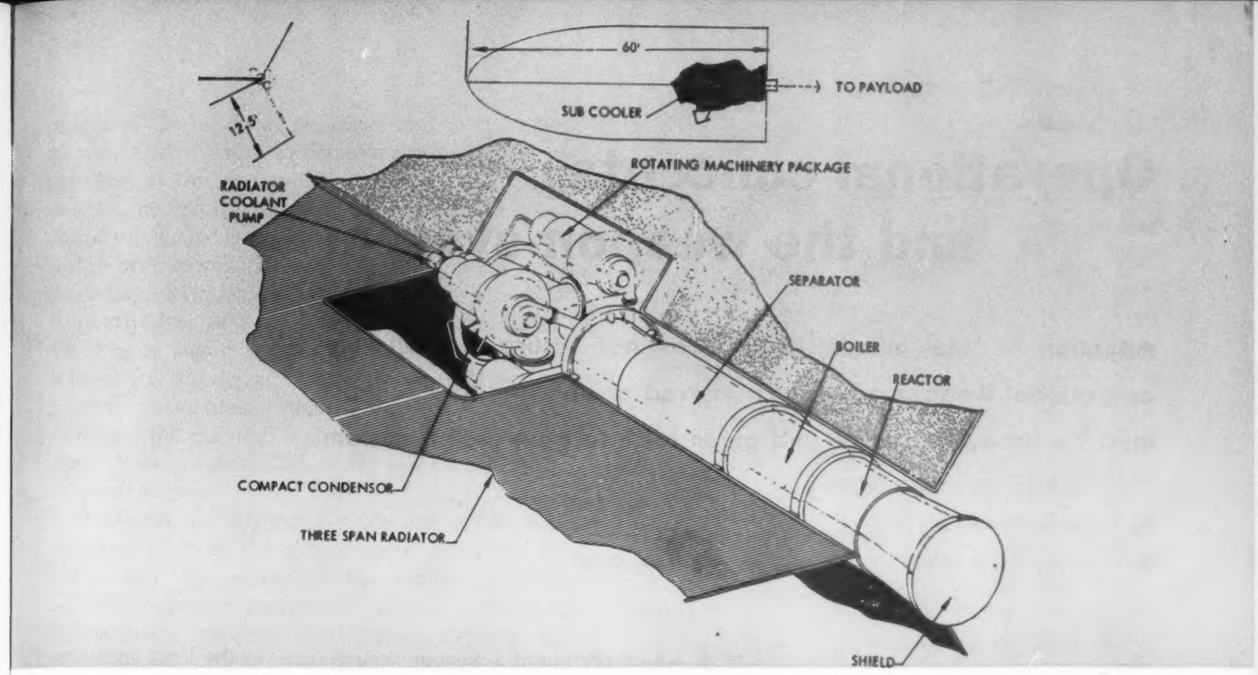
By D. P. Ross, E. Ray, E. G. Rapp, and J. E. Taylor

TAPCO GROUP, THOMPSON RAMO WOOLDRIDGE INC., CLEVELAND, OHIO

The need for a compact, light-weight, long-life source of electrical power for space applications is well known. Research and development work in the low and intermediate powers, as exemplified by the Snap programs, is well advanced. But a need for electrical power generating units in the megawatt range can be anticipated. This need arises particularly with development of high-performance electrically powered vehicles for missions such as interorbital shuttles, satellite sustainers, and lunar and interplanetary trips. The propulsive power requirements for a majority of these missions lie in the range from hundreds of kilowatts to several megawatts. For example, one such mission is the round-trip transfer of a 32,000-lb vehicle from a 200-mi orbit to a 24-hr orbit using ion propulsion.

D. P. Ross joined TRW in 1954 as a design engineer in nuclear reactor technology, after receiving an M.S. in E.E. from Columbia Univ., and is now a research engineer in space power applications. His participation in TRW's pioneering engineering in the space-power field led him to continue his studies with advance training in nuclear reactors at the Oak Ridge School of Reactor Technology, and currently he is a candidate for a doctorate in M.E. at Case Institute of Technology, where he has been a special lecturer in nuclear engineering.

E. Ray, a senior engineer with Tapco's space power systems group since 1959, received an M.S. in mechanical engineering from Cornell Univ. in 1955, and after a year with WADD, working in propulsion, joined TRW as a research engineer. He has since contributed to a number of its programs, and has supervised the analysis of a variety of advanced power-generation schemes. His background includes experience designing production machine tools and instructing in machine design at Cornell.



1-Megawatt Powerplant Design

An electrical powerplant generating 1 megawatt can supply both propulsive and auxiliary power for this mission. Exclusive of powerplant, reactor shielding, propellant and propulsion system weight—a manned payload of 19,000 lb can be carried by such a vehicle. Studies at TRW indicate that little or no shielding is required to protect the manned payload from the radiation region surrounding the earth if the components of the payload and propellant are integrated into this shielding. In comparison, a 32,000-lb two-stage chemical-propellant vehicle with a specific impulse of 350 sec can return a payload of only 2500 lb for the same mission. And this 2500-lb payload must include the electrical power supply, thus reducing the utility payload even further.

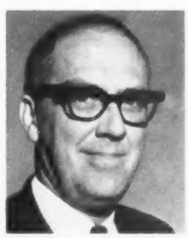
Within the next few years, the Saturn vehicle will supply a capability to boost payloads up to 32,000 lb into a low-altitude orbit. The effective use of Saturn boosters requires the initiation of the development of large electric powerplants immediately. Our discussion here will illustrate the technical considerations involved in the selection of a 1-megawatt powerplant concept and present a resulting powerplant design.

Reliability and Weight Criteria

The conceptual design of a 1-megawatt powerplant is influenced by the performance criteria selected. We consider reliability and weight of prime importance.

In selecting a space (CONTINUED ON PAGE 72)

E. G. Rapp is currently engaged in the technical and business management of nuclear metal-vapor and solar turboelectric Rankine-cycle power systems for space-vehicle guidance, communications, and propulsion. His background includes an M.S. in engineering mechanics from Case Institute; analysis and design of stressed skin structures and landing gears with Chance Vought; six years as an instructor in theoretical and applied mechanics at Case Institute; and a variety of supervisory work at TRW since 1952 on auxiliary power systems, including Snap 1 and Snap 2.



J. E. Taylor, manager of Tapco Group's New Devices Laboratories in Cleveland, led the team which did pioneering work five years ago in nuclear space-power-conversion systems, more recently worked on solar and fossil energy systems for the NASA Sunflower and WADD Spud programs, and has been active in electric propulsion. His background includes a B.S. in C.E. from Rose Polytechnic Institute and an M.S. in M.E. from Ohio State Univ. He was an aeronautical researcher at WADD during the war and a member of the NACA subcommittee on powerplant controls. He holds eight patents.

Operational concepts and the weapon system

Attention to the missile itself does not insure a valuable operational weapon system; a myriad of operational concepts must be brought to bear and given form to gain such a system

By Peter B. Weiser

SPACE TECHNOLOGY LABORATORIES INC., LOS ANGELES, CALIF.

Peter B. Weiser is a member of the technical staff of STL's Atlas Project Office. His professional experience began with the Navy in WW II as a physicist in charge of degaussing and deperming operations, just after he received a degree in physics from Hofstra College in 1940. After receiving an M.S. in physics from UCLA in 1950, he joined the U.S. Naval Ordnance Test Station, China Lake, Calif., doing research on homing torpedoes and the exterior ballistics of small rockets and acting as a technical editor on rocket projects. Later, at Rocketdyne, he was supervisor of operations research on large liquid-propellant rocket engines, and then joined the staff of STL in 1957. He is the author of numerous technical papers and the co-author with Kenneth Brown of a coming book on ground-support systems for ballistic missiles and space vehicles, to be published by McGraw-Hill.

THE MAJOR portion of a weapon system receives the least attention until it is too late. In general, during the technological life of a weapon system, the first emphasis in the early phases is almost strictly applied to only the flyable—or missile—portion. A considerable amount of the emphasis wrongly placed has come from the improper definition of the place of the missile in the weapon system. Considering only the Air Force viewpoint, the evolution of the thinking about the ICBM started with the airplane. The airplane was the unit of prime mission equipment, carrying the lethal load from airfield to target. In those days, the support systems, excepting the airfield, comprised only about 20 per cent of the entire weapon system. Although their weight was important, the aircraft was still capable of carrying guidance, bombing, and communication systems, and many other subsystems, on the mission.

When missiles came along, the first types were air-breathing. They looked like bombers, and hence were considered pilotless bombers. When the ICBM was born, this belief had been firmly set; and although the words "pilotless bomber" went out of fashion, the ICBM assumed the place of the airplane as the prime mission equipment in people's thinking.

Do we have legitimate parallels between long-range missiles and bombers? ICBM's do not carry personnel, at the simplest level of divergence, and major portions of the equipment normally carried aboard bombers must be left on the ground.

Missiles Bring a New Emphasis

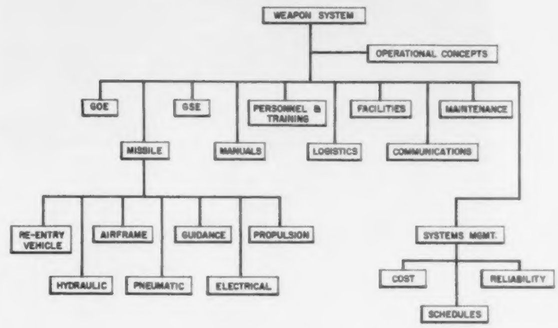
Certainly the balance of equipment for the two represents a different emphasis. In the airplane weapon system, much of the support system could be carried along in the flight. In the missile weapon system, where weight is much more critical, most of the support system *must* be left on the ground—to the extent that the ground-based systems comprise 80–85 per cent of the entire weapon system.

This 80–85 per cent of the weapon system made up of support system received, we believe, short shrift during the early days of the development programs for missiles. Even now over-

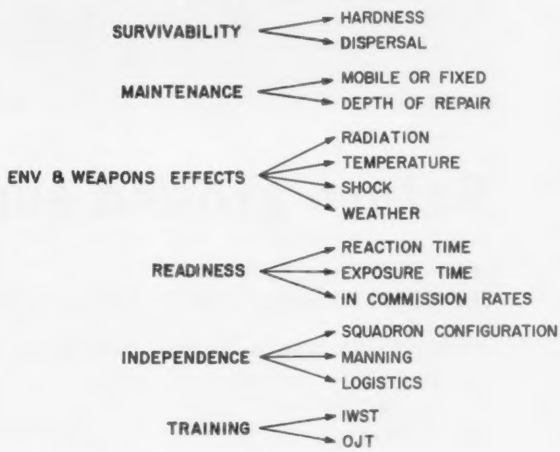
emphasis—in technical programs and in the newspapers—on the desire to obtain a flyable missile, regardless of the operational capabilities of such a design, inevitably will result in slippages in operational dates, makeshift operational support systems, and, worse, redefinition of the meaning of the words "operational capability." There was near surety in the early days of missile development that indeed the missile would fly; but minor difficulties in design, overly publicized test flights which failed, and a tendency to react violently to Cold War stimuli obscured the essential fact that the design was flyable. In consequence, all other phases were ignored to some degree.

Obviously, the support systems did receive some attention early in the development programs, but not nearly the same as the missile received. Ground-support equipment, training, manuals, maintenance, logistics, facilities—all support systems—do not appear as glamorous or as important as the missile. The general feeling appeared to be that no basic new principles were involved in the design of the support system. Facts seem to dispute this. Some 85–90 per cent of all support-system equipment is peculiar to the missile for which it is designed. Standard equipment cannot be used. This is dictated not only (CONTINUED ON PAGE 52)

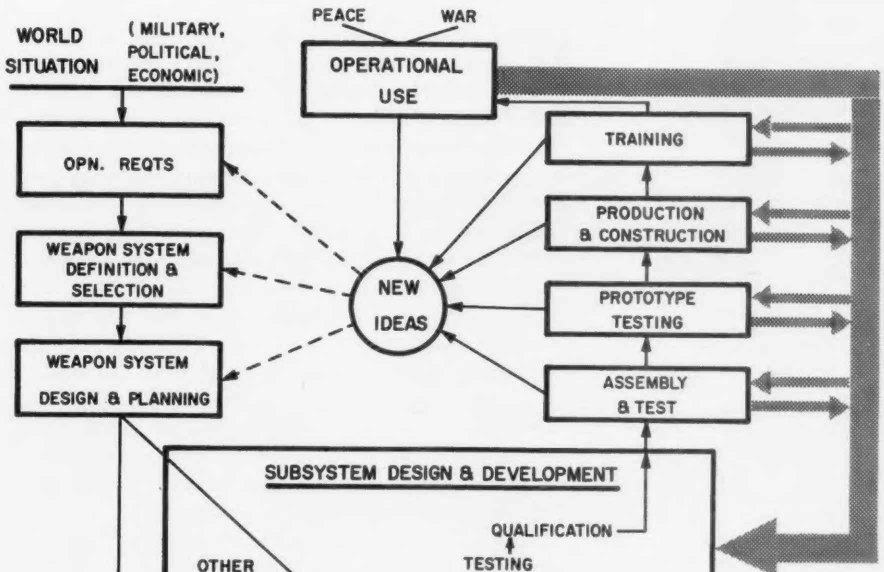
Weapon System Definition

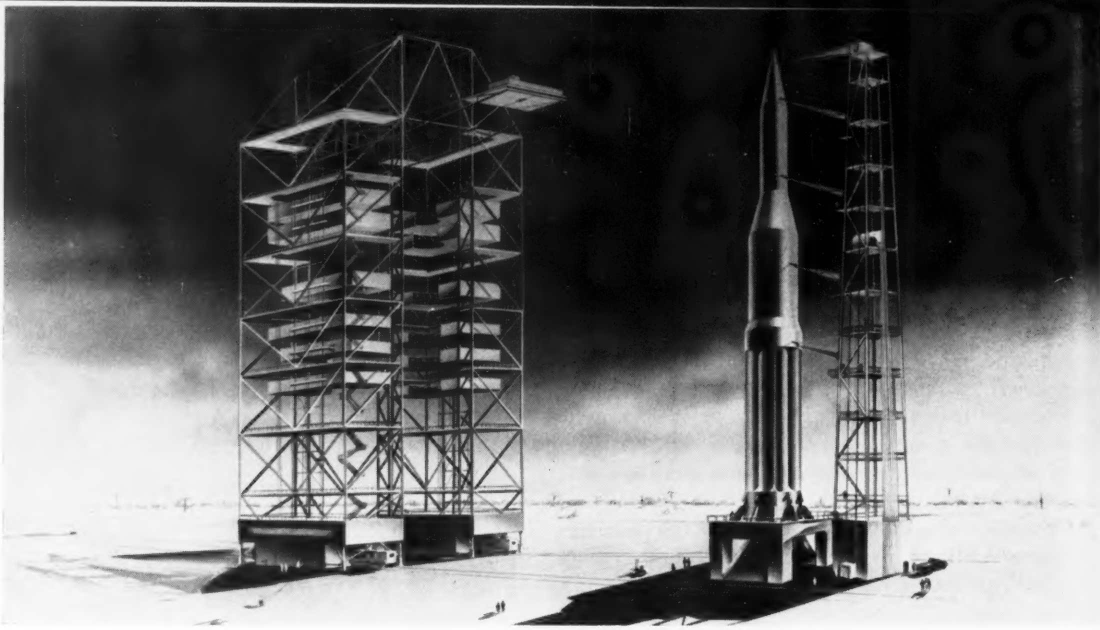


Operational Concepts



Ideal Weapon System Life-Cycle





Saturn ground support and operations

The unprecedented Saturn launch and support facility gives an index to space-flight operations in the coming decade

By Georg von Tiesenhausen

NASA GEORGE C. MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.

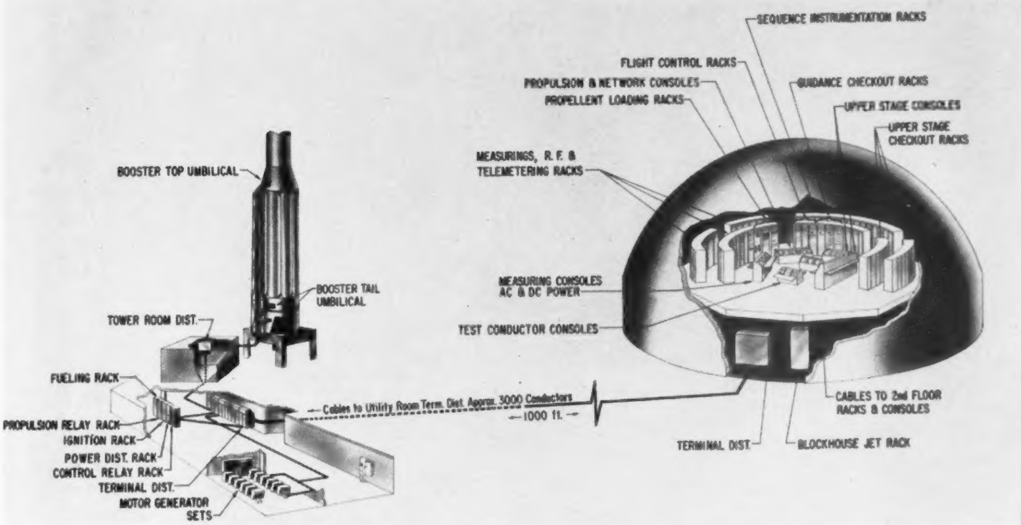
Georg von Tiesenhausen, after receiving a degree in mechanical engineering in Hamburg, Germany, in 1943, worked at Peenemuende on the development of V-2 and Wasserfall rocket test stands, and worked on the design of the first submarine missile launcher. He came to the U.S. in 1953, joining ABMA at Huntsville, where he held development responsibility for the tactical Redstone launch system, a new missile erection concept, the Jupiter launcher and erection system, and the Saturn launch system. He is at present studying future launch-system requirements for NASA's Marshall Center, and has a patent on a rocket tail grab mechanism used on Jupiter and Saturn.

With the advent of the first large space vehicle, the Saturn, the ground-support-equipment (GSE) and launch-facility designer is faced with the necessity of conceiving and building an unprecedented launch system concurrent with the vehicle development. We will attempt to present a comprehensive picture of the problems involved and how they are being solved, following the Saturn vehicle through the various modes of operation, such as transportation over land and water, checkout, handling and erection, and propellant loading, and describing the facilities at the launch site.

Conceiving and developing launch equipment and facilities for space vehicles pose problems of considerable magnitude, because many areas are without precedent. Time schedules do not allow for experimenting with various approaches, so the first approach has to be the right one or you run into a dead end and large funds are wasted. This way of working without precedent has become a necessary habit of those involved in this business and requires a conceptual design based mainly upon a vast experience built up through several generations of missiles.

However, facilities and GSE for space vehicles deviate in many respects from those familiar to many of us with IRBM's and ICBM's. The main difference is that, where one could, with these missiles, allow for possible failures in the initial phase of flight testing and thus depend on this ultimate means of proving the design, this approach cannot be afforded with a space vehicle worth many

EQUIPMENT LAYOUT AT CAPE FACILITY



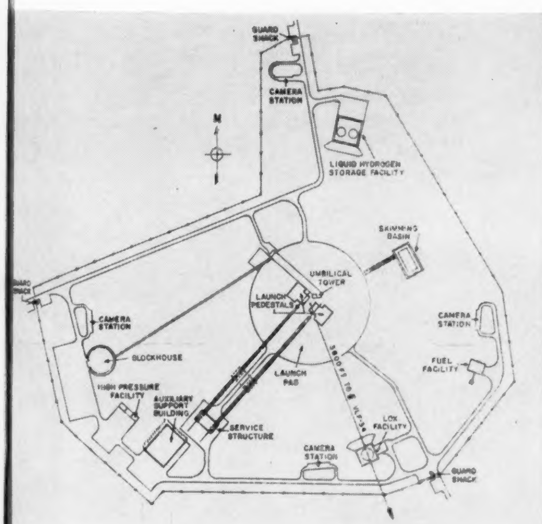
millions of dollars. Failures due to malfunction of GSE in particular cannot be tolerated.

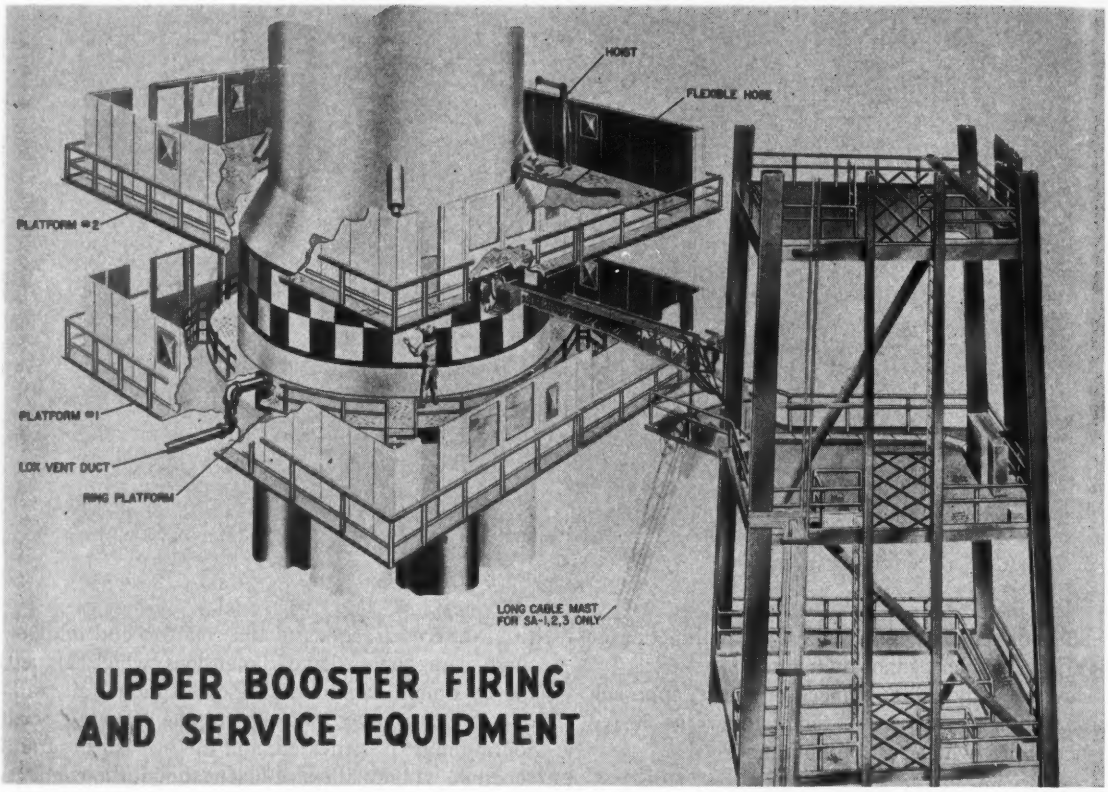
How can the GSE project engineer approach these problems and solve them under the heavy responsibility which rests upon him?

Logistical Considerations

Logistical support of the launching of lunar-mission Saturn vehicles from the Atlantic Missile Range (AMR) will present major transportation problems. The four major vehicle components (booster, second and third stages, eventually a fourth stage, and payload) must be shipped to AMR from different sections of the country, and most of these components have dimensions which exceed the maximum capabilities of conventional air, rail, or road carriers. Special equipment and special routing must be provided, and the over-all program schedule will not allow sufficient time for movement of these items at the most convenient times consistent with other transportation activities.

The Saturn booster to be transported from Marshall Space Flight Center to AMR in an assembled condition will be 256 in. in diam and approximately 82 ft long. Since the booster will be moved on its transporter, these dimensions will become even larger. The only practical way to transport this vulnerable item appears to be by waterway.




HOIST
FLEXIBLE HOSE
PLATFORM #2
PLATFORM #1
LOX VENT DUCT
RING PLATFORM
LONG CABLE MAST FOR SA-1,2,3 ONLY
UPPER BOOSTER FIRING AND SERVICE EQUIPMENT


LOWER BOOSTER FIRING AND SERVICE EQUIPMENT
1 FUEL FILLING MAST
2 SHORT CABLE MAST NO. 2
3 TAIL HEATER COUPLING
4 LONG CABLE MAST
5 VALVE BOX NO. 2
6 RETRACTABLE SUPPORT ARM
7 FUEL FILLING PIPE
8 FUEL ADJUST LINE
9 FUEL LINE
10 WATER LINE
11 HYDRAULIC SERVICER (4)
12 ENGINE SERVICING TRAILER
13 ENGINE SERVICING PANEL
14 ENGINE SERVICING DIST.
15 CABLE TROUGH
16 HOLD DOWN ARM
17 LEAK TEST PANEL
18 SHORT CABLE MAST NO. 4
19 BOAT TAIL HEATER
BASE ROOM

The already widely discussed barge transportation will assure safe handling of the cargo, but will require between two or three weeks for the transportation phase alone. Handling of the booster after a successful landing and recovery also constitutes a major operation. The operation of spotting and water recovery of re-entry nose cones is well known. However, the water recovery of a small and compact nose cone is far more simple than that of a voluminous and delicate booster which is partially filled with propellant residuals, and which presents a safety hazard to equipment and personnel. Details of the proposed water-recovery scheme are discussed later. A Landing Ship Dock (LSD) is proposed as the main equipment. Flushing, inspection, preservation, and disassembly of delicate parts will be done onboard ship by a special crew during the return trip. Later, the vehicle will be transferred to a river barge for return to Redstone Arsenal (RSA) dock. A suitable harbor with proper crane facilities, such as New Orleans, will be used for this purpose. Preparation, recovery action, and return to New Orleans will require an LSD for about one week and supporting ships for a portion of this time.

Transportation to Launch Site

A part of the booster final-assembly jig is used to make up the transporter assembly. The assembled booster, with its support cradles, connecting trusses, and assembly rings, is jacked up as a unit and placed on two axle-and-wheel assemblies. Each wheel assembly consists basically of two pairs of two independently braked and hydraulically steered aircraft tandem wheels on an axle assembly. The support cradles are secured to the axle assemblies and a towbar on the forward assembly connects to the prime mover. The booster is carried on this composite vehicle through all phases of testing, checkout, and transportation from the fabrication plant to the launch site. The maximum towed speed of the loaded transporter is between 3 and 5 mph. The maximum angle of approach and departure is 13 and 17 deg, respectively.

Docking Operations

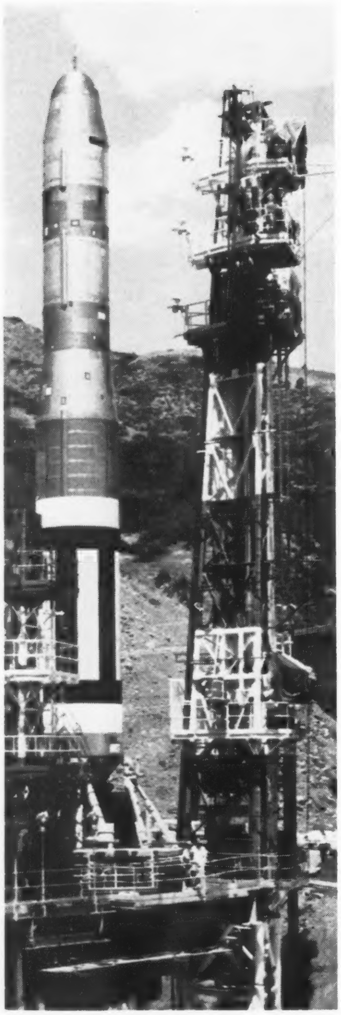
After all booster testing at MSFC is completed, the booster-transporter combination is towed to the RSA dock and is rolled onto a specially designed barge. The dockside facilities for this operation consist of a ramp to the water's edge and two electrically powered winches mounted at the top of the ramp to control movement of the transporter up and down the ramp. An undamaged booster returned to RSA dock on a transporter will be off-loaded in a similar manner. However, if a heavily damaged booster is returned, it may not be supported on a transporter, and partial salvage operation may be necessary before off-loading is accomplished. In this case, lift (CONTINUED ON PAGE 78)

A different approach to GSE

Form and function take on new meaning in ground-support and ground-operating equipment as the Air Force moves into advanced missile and space systems

By Lt. Col. Theodore O. Wright, USAF

AF BALLISTIC MISSILE DIV., LOS ANGELES, CALIF.



A Titan test vehicle up on the stand at Martin-Denver that allows sequential static testing of stages.

SINCE the inception of the Western Development Div., Hq ARDC, later changed to the Air Force Ballistic Missile Div., adequate ground-equipment systems in support of ballistic missiles have presented many varied and difficult problems to the weapon-system directors.

These problems primarily stemmed from two conditions: The ballistic-missile development programs were the shortest in the history of the Air Force; and ground equipment tended to be treated in the time-honored fashion of support equipment. Here the development cycle was shortened from 8 to 10 years for a major aircraft weapon system to less than 3 years for a ballistic missile, the IRBM. For the ICBM's this period was shortened to something less than 5 years. To do this we had to adopt the philosophy of concurrency. Even in managing a program of concurrency some things must come first. This created problems if ground equipment was placed in the support role, because then its design criteria had to follow that of the missile. On the other hand, the ground equipment necessary to launch the missile had to be designed, manufactured, and installed and launching positions had to be activated concurrently with missile development.

As can be readily seen, this type of operation not only created many problems, but also had a tendency to create unnecessarily complicated ground equipment. By the time the Titan program was entering the first testing phases, it became apparent that to meet the operational dates the old, tried-and-true methods used for ground equipment would have to be changed. I am referring here to the methods used for ground-support equipment for aircraft and smaller missiles developed before 1956.

Beyond Simple Ground Support

A careful examination of a ballistic missile, or in fact any missile which is ground-launched and contains its own guidance, reveals that more than ground-support equipment is required for a successful launch. This becomes readily apparent if we examine the definition of ground-support equipment. An accepted definition is as follows: The term "Ground Support Equipment (GSE)" refers to non-airborne implements or devices which are required to inspect, test, adjust, calibrate, appraise, gauge, (CONTINUED ON PAGE 92)

Kodak reports on:

aiming information into the eyes . . . the sweetest little old solid-state amplifier and transducer known to man . . . strong stuff for the infrared

The final transfer

For an honest purpose these able gentlemen have consented to the indignity of posing a tableau in supercharged staring. Because they and numerous unpictured coequals are personally involved, they wish to call attention to a certain technical area in which we think we are good. It deals with the art of projecting information into human eyes, the final transfer from machine to man.

The black rectangle labeled "Special Kodak screen" stands for a multitude of possibilities, some which we have already demonstrated and others needing more study. Study, as is well known, costs money. It would be smarter use of the money to do the studying in the context of specific viewing and display requirements—review of vast volumes of reconnaissance photography, for one currently popular example. The composition and design of the screen should not be considered in isolation from the projectors, the eyes, the restrictions on their location, the ambient light, the nature of the visual task, and all the other pertinent factors.

On this broad and subtle subject we have neither off-the-shelf literature nor off-the-shelf products, but we are anxious to be in contact with those whose interest in it is more urgent than academic. Such persons should communicate with Eastman Kodak Company, Apparatus and Optical Division, Rochester 4, N. Y.

Rapid-access photography

The silver halide crystal of suitable size and suitable dislocations, with a suitable organic compound or two clinging to it, makes the sweetest little old solid-state amplifier and transducer known to man. It is doing just fine, despite a few misconceptions that have arisen due to the following circumstances:

1) The idea was developed by artists before words like "solid-state physics," "amplifier," and "transducer" were coined and even before science was recognized as profitable.

2) The crystal is employed in very large numbers, dispersed in a dried-down broth from hides and bones. Superficially regarded, this seems archaic. By referring to the preparation as a "photographic emulsion," the notion is dispelled.

3) Memories from childhood suggest that after a photographic emulsion is exposed, one must wait until Dad brings the results home from downtown the week after next. This is no longer true.

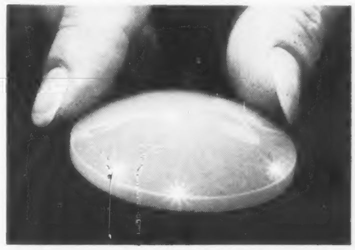
Purpose of this message is to make it perfectly clear that today the delivery of photographic results within virtually any desired time interval after exposure is wholly feasible technologically. There are many ways of accomplishing quick delivery, some currently on the market and others on the way. The manufacturer wagers on what the public will buy. As far as goods for the general public are concerned, that's the way it has to be. But on goods for the professionally technical public—rational, organized, deliberate, articulate—*must* the betting be so blind?

We have had a flash of genius. Let's ask them first what they want! Then, as patterns appear in the answers, markets can be defined and gauged. If this works, rapid-access and simplified technical photography will encounter fewer custom problems to be solved at custom prices or else given up for less satisfactory alternatives.

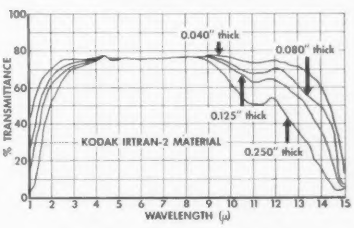
Responsible organizations confronted with technical problems, major or minor, where rapidly or instantaneously available photographic images would be helpful, are invited to describe their wants to Eastman Kodak Company, Special Sensitized Products Division, Rochester 4, N. Y.

Like a diamond, but we can fix that

There used to be only one kind of Kodak Irtran optical material for the infrared. Now there are two. The second is called *Irtran-2.*



See how it shines. It shines because its refractive index is more than 2.2. If it didn't have such a high refractive index it wouldn't shine so much. Neither would it make such strong lenses and prisms. But for the energy bounced back in shining, the transmittance



would be even much higher than it is. As it is, the transmittance is nothing to be ashamed of. You don't have to take it as it is. By heating it up to 800°C in the very air you breathe, you put an anti-reflection coating on it (and that's all you do). We can apply a much better coating, though, by evaporation.

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TRADEMARK

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

Careers in astronautics

By Irving Michelson, *Illinois Institute of Technology*

DEVELOPMENTS in fuel cells, solar cells, and other space power sources are recognized as shining examples of astronautical progress—and justifiably so. However, there are indications that real progress in this area has only just begun. At the recent ARS Space Power Systems Conference, it was noted that vastly greater amounts of electrical power will be needed in manned space vehicles, and this calls for design refinements which are now entirely out of reach. This particular branch of astronautics is one which relies heavily on a number of different scientific and technological disciplines, each contributing to the others in an essential way.

For instance, it has become increasingly clear that vastly improved high-temperature materials are essential before any breakthroughs can be expected, while improved design efficiencies require major weight reductions. Both problems fall in the domain of the solid-state physicist and the materials engineer, while electrochemical properties and systems design considerations are of crucial importance over-all. A related problem is that of heat rejection in space, and how to remove unusable heat at low temperatures in an air-free and gravity-free environment.

A number of companies—Ionics, Inc., Electro-Optical Systems, Pratt & Whitney, through its recently organized Physico-Chemical Lab, and Kollsman Instruments, through its new Research Div., to mention only a few—are now engaged in research in these fields. Physicists, physical-chemists, solid-state technicians and engineering-physicists are likely to be attracted to these new activities in what is certainly one of the fastest-growing fields in the entire space business.

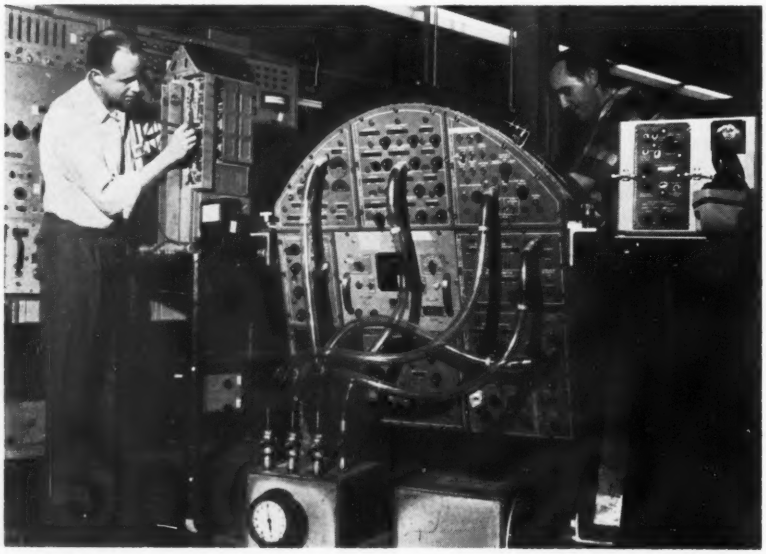
° ° °

A year or more ago it might have struck us as a bit odd that some of our major space-vehicle developers were showing an interest in oceanography, but the tables are almost completely turned now, when a group *not* deeply involved in studies of ocean dynamics, underwater optics, acoustics, and related problems appears to be the exception. As soon as we think about re-entry bodies, or the advantages of launching from completely mobile bases, however, it seems entirely appropriate to study the vast spaces right here on earth, which are in reality the biggest and closest "space laboratories." In addition, of course, many things of scientific value are likely to be learned by studying the oceans by completely up-to-date methods. Grumman's role in these programs has been an important one, and we hear that it is expanding even further.

The Navy, with its own special interest in a class of space vehicles, encourages these studies, creating a steadily growing demand for oceanographers, hydrodynamicists (theoretical as well as experimental), systems analysts, operations researchers, and acousticians. To get some measure of this activity, we find that congressional appropriations covering this work total a staggering $1.4 billion for FY 1961, under the heading of antisubmarine warfare, and this figure may be doubled next year. While some 90 per cent of this amount has nothing at all to do with science or research, which is lumped together with development, test, and evaluation, oceanography may still be substantially benefited by the remaining indeterminate fraction. Perhaps even more hopeful, though, from a basic point of view, is a planned appropriation to cover a 10-year program for oceanographic research, strongly recommended by NAS a year ago. It is considered likely that this measure will be passed in the next session of congress.

° ° °

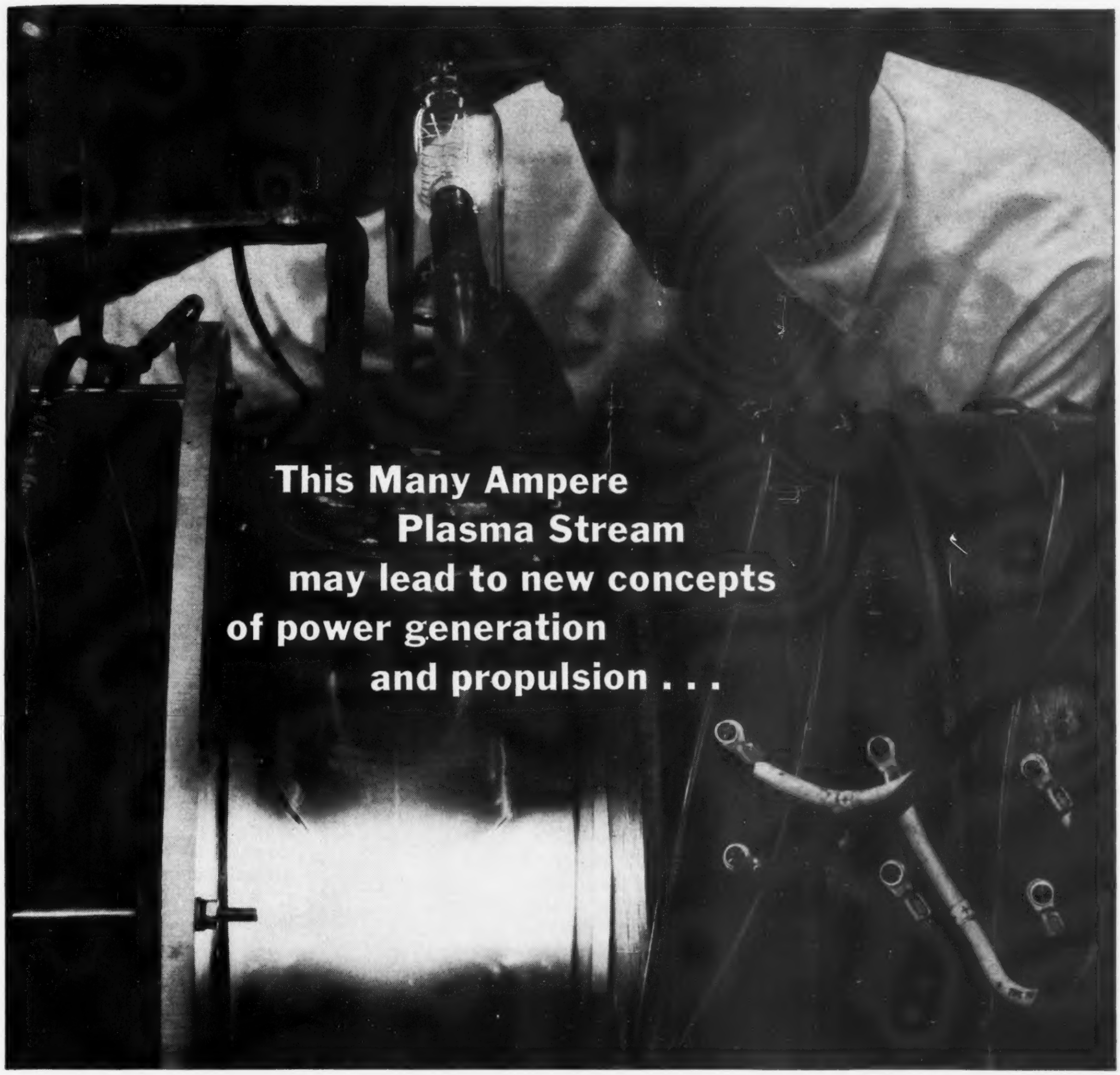
Reliability problems seem once again to be coming to the fore, creating anew the clamor for reliability engineers. Electronic components and systems still seem to be the worst offenders, and much attention is also being directed at manufacturing methods. In another area, determination of reliability measures is being sought in relation to the development of automatic weather recording instruments and associated communications systems. Mathematicians and statisticians, working closely with solid-state experts and process engineers, have made some important progress in formulating a theory of reliability, but much theoretical work is still needed.



Reliability Realm

Engineers checkout the prime bombing and navigation system of the B-58 supersonic bomber at Sperry Gyroscope, which developed and is manufacturing the system.

For specific career opportunities this month, see Second and Fourth Covers, pp. 1, 2, 4-5, 11, 16-17, 18, 37, 39, 51, 54, 55, 57, 59, 61, 75, 89, 93.



A many-ampere source of ions, this device is believed to be the most powerful in operation in any laboratory. Already it is providing new insight into thermonuclear fusion. It may lead to new concepts in propulsion including a method of producing thrust for missions beyond the earth's atmosphere.

Accomplishments like this are the result, we believe, of a unique research environment. Among other things, we encourage independence of scientific thought and action. And, we make determined efforts to free scientists from tedious routine — help direct their full mental powers towards scientific achievement.

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Rocketdyne Proposal For Sounding Rocket

This full-scale model shows Rocketdyne's concept of a sounding rocket capable of propelling a 6-lb payload to an altitude of 230,000 ft. Designed at Solid Propulsion Operations, McGregor, Tex., the rocket measures 105 in. long by 4 in. in diam, and employs a single star-perforated solid-propellant grain. Note the tangentially folding fins, which would allow tube-launching. The rocket was flight-tested recently.

Snap 2

(CONTINUED FROM PAGE 25)

Ramo Wooldridge (Thompson Products) near the end of that year.

Initial emphasis was placed on the development of materials, physics, and components necessary for successful concept feasibility demonstration. The operation of a zirconium hydride critical assembly in October 1957 provided experimental verification of reactor-analysis techniques. Successful mercury-turbine tests in November 1958, and bearing tests one month later, substantiated major portions of the power-conversion system. The completion of an inpile irradiation of fueled zirconium-hydride in January 1959 was a significant milestone. The fuel samples, of the required characteristics, were subjected to twice the Snap-2 burnup at the expected thermal stresses and temperatures without mechanical damage, change in thermal conductivity, or change in hydrogen dissociation pressure. In June 1959, the Snap Experimental Reactor (SER), shown on page 25, was taken to criticality for various measurements. It was then reassembled in the SER Test Facility, tested at low power and temperatures, and then, in October, taken to rated power and temperature. It has since logged many more than 1000 full-power hours in addition to having provided a great deal of off-design point operational data. The Combined Rotating Unit (CRU), shown on page 25, for the power-conversion package was successfully tested by TRW in September 1959. It has since been subjected to an endurance test.

Major Subsystems

Snap 2 consists of two major subsystems—the reactor heat source and the power-conversion unit. A schematic on page 25 illustrates the system. Energy is produced in the nuclear reactor by the fissioning of U-235. A liquid-metal (NaK-78) heat-transfer fluid is circulated through the reactor core and the mercury boiler superheater by a rotating permanent magnet pump. In the boiler superheater, the reactor heat is transferred from the primary reactor coolant to the mercury working fluid of the Rankine power-conversion cycle. The reactor heat converts liquid mercury into superheated vapor which is expanded through a turbine. The resulting mechanical power output of the turbine is converted to electrical power by the alternator. The mercury-vapor exhaust from the turbine is condensed in the radiator-condenser, which is part of the outer skin of the space vehicle. Because of the space environment, the cycle rejection temperature must be maintained by radiative heat rejection only. The mercury condensate is returned to the boiler by a boiler-feed pump. Snap 2 thus incorporates the major components of a conventional nuclear electric plant with the following exceptions: The cycle working fluid is mercury instead of water, and the cycle heat rejection is by radiation to space instead of to a conventional heat sink, such as a river or ocean.

The Snap-2 reactor is shown schematically on page 25. The reactor employs a homogeneous fuel moderator of zirconium hydride containing U-235. For minimum weight, the reactor is reflected by beryllium and controlled by variation of the effective reflector thickness by means of angular rotation of two semi-cylindrical beryllium drums. The core is composed of a bundle of cylindrical fuel-moderator elements. Beryllium slugs, located at both ends of the fuel elements, form the reactor end-reflectors. Each fuel element is clad in a thin-wall steel tube for liquid-metal exclusion. The steel-clad tubes are internally coated to prevent hydrogen loss from the fuel-moderator material. The core is contained in an approximate 9-in.-diam-core vessel, with the beryllium radial reflector outside the vessel. The reflector is completely separable from the core for safe reactor shutdown and handling. The 50-kw thermal output is removed by the flow of NaK-78 axially through the core within the interstitial passages between the fuel elements. The coolant enters the core at 1000 F and exists at 1200 F.

All the power-conversion-system rotating components are mounted on a single common shaft which is called the combined rotating unit (CRU). Thus, the entire Snap-2 power-conversion system has only one moving part, which is supported on bearing pads by liquid mercury. The CRU is shown schematically and as it looks as hardware on page 25. The individual components of the rotating shaft include:

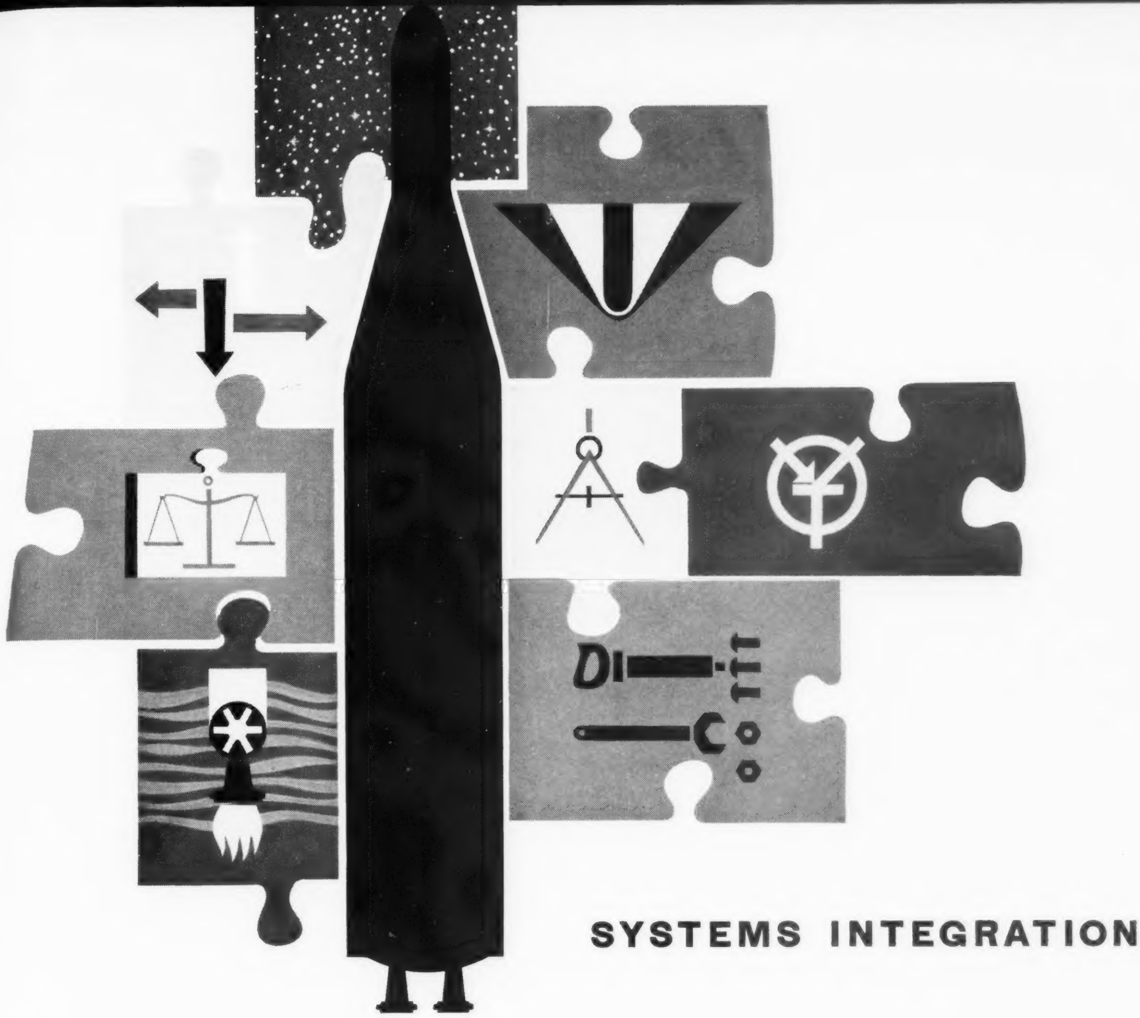
1. The rotating permanent magnet NaK pump, whose operation is similar to that of a conventional E-M pump, with the exception that the moving magnetic field is provided by a rotating magnet.
2. The mercury turbine, which is a two-stage axial-flow impulse machine.
3. The alternator, which is a permanent-magnet machine with a sealed stator; the alternator delivers about 3.5 kw at 110 v and 2000 cps.
4. The mercury pump, which is a conventional but miniature centrifugal pump, supplying pressurized mercury to the boiler and to the bearings.

All the rotating components—the NaK pump, turbine, alternator, and mercury pump—are mounted on the shaft, which rotates at 40,000 rpm. The shaft is supported by liquid-mercury-lubricated journal and thrust bearings. The entire assembly of rotating machinery is enclosed within a hermetic housing, which prevents the loss of the mercury working fluid.

The mercury boiler-superheater is a concentric tube, counterflow, once-through boiler with NaK in the outer annulus and mercury in the central tube. The boiler is in a helical configuration to provide an artificial-gravity environment by centrifugal acceleration.

Heat Rejection

The cycle rejection heat is radiated to space by a combined radiator-condenser, which forms part of the outer structural skin of the space vehicle. Mercury condensation takes place at 600 F and 6 psia within a number of small-diameter parallel tubes attached to a high thermal conductivity (aluminum) skin, which in turn radiates the



SYSTEMS INTEGRATION

Systems Integration, a major endeavor at Lockheed, involves the responsibility of establishing and maintaining composite system and subsystem characteristics within the parameters necessary for a successful development of weapon and satellite systems.

An outstanding example of this system's engineering approach is illustrated by the Navy POLARIS Fleet Ballistic Missile Weapon System. The Navy gave Lockheed Missiles and Space Division the basic overall weapon system requirements and the required operational date, and requested Lockheed to develop a missile system compatible with the other systems of the weapon system. This demanded an entirely new procedure in missile development: 1) The design had to be based on anticipated advances in the state-of-the-art to meet performance requirements. 2) Simultaneous development of missile subsystems in an independent fashion was required to meet time scale requirements. Not only is Lockheed meeting these requirements—*it is delivering an operational missile system three years ahead of the original schedule.*

Detailed functions of successful systems integration activities include: Establishment of basic system characteristics through use of preliminary design and parametric study techniques; sectionalizing the missile and defining interfaces and performance requirements for each subsystem; monitoring and counseling the design activities of subsystems and establishing interfaces and subsystem design parameters and tolerances; assuring and maintaining design compatibility of subsystems throughout the entire development of the missile into the weapon system.

From the development of advanced system proposals into the preliminary design and system requirements, on through to final missile production, demands highly trained engineers and scientists in missile and space technology concerned with the overall systems problems.

Engineers and Scientists: Work in the broad spectrum of systems integration functions provides a constant challenge at Lockheed Missiles and Space Division. If you are experienced in this area, you are invited to write: Research and Development Staff, Department L-14, 962 W. El Camino Real, Sunnyvale, California.

U.S. Citizenship or existing Department of Defense industrial security clearance required.

Lockheed / MISSILES AND SPACE DIVISION

Systems Manager for the Navy POLARIS FBM; the Air Force AGENA Satellite in the DISCOVERER, MIDAS and SAMOS Programs

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA
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heat of condensation to space. The total area necessary to radiate 40 kw at 600 F is about 100 ft^2.

The 600-lb Snap-2 system will have the following approximate weight breakdown:

- Reactor—200 lb
- Boiler—100 lb
- CRU with insulation and mounting brackets—50 lb
- Radiator with liquid inventory—150 lb
- Controls—20 lb
- Structure—50 lb
- Piping—30 lb

At present the feasibility of both the reactor heat source and the power-conversion-system components have been proven individually. One of the next steps involves the marriage of all the system components in a breadboard assembly so that the over-all system behavior may be studied.

Reliability Testing

After verifying the integrated system operation, using the prototype components, it will be necessary to test all components for reliability and for their ability to withstand the environments of launch, space operation, and nuclear radiation. With a set of proved components and subsystems, a design of an integrated package can be completed. After non-nuclear testing of the packaged unit, a nuclear test can be made. Extensive instrumentation is required in order to produce meaningful test results. The basic system exclusive of readout instrumentation is, however, simple and uncluttered.

Throughout the development program, the unique test facilities at Santa Susana, Calif., and remote handling equipment will be used, since the reactor, as it finally develops into a space system, is essentially an unshielded unit with no provision for direct manned operation and maintenance.

Moreover, the environmental conditions of the application must be considered at all times. Typically, steady-state acceleration of 10 g, shock of 60 g, and 15-g vibration tolerances must be provided. The associated test program is relatively straightforward for the case of orbital startup; but if ground startup is required, the tests must be made on operating NAPU's—a much more complex task. However, the test facility is designed to handle these tasks.

The demonstration of high reliability for such a costly and long-lived system is difficult. But the cost of launching a major space system is such that a demonstration of reliability may be economically desirable. Studies have been made that relate cost of reliability demonstration to the over-all cost of a particular satellite or space vehicle.

Vehicle Application

What of vehicle design itself? A NAPU offers many advantages to the designer of long-lived satellites and space vehicles. Snap 2, for example, furnishes 3 kw of well-regulated electrical power with a system weight of approximately 600 lb unshielded or about 900 lb shielded (this is highly dependent on vehicle design, as is shown later). This corresponds to about 5 watts per pound or, on an energy basis, some 50,000 watt-hours per pound. There is no sun-shadow transient and no orientation problem, as with a solar unit. Integration of the NAPU into a vehicle is straightforward if the designer is familiar with the characteristics of the nuclear system. Unfortunately, little information is now available in the open literature that is of any great use to the designer. Since such information is vital to the ultimate utilization of a NAPU, the following discussion will present some of the considerations which may lead to a good design.

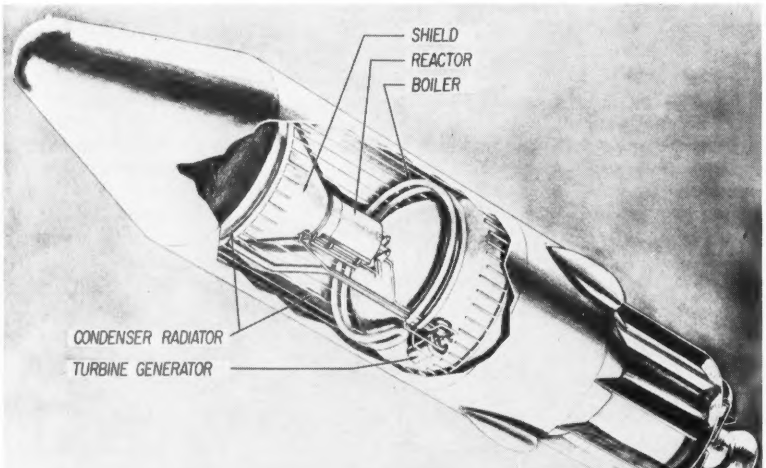
Where to Put It?

The major problem presented to the designer concerns the APU location with respect to other components of the vehicle system. There are many ramifications to this choice of location that must be considered before an optimum design can be obtained. For example, the reactor-and-shield combination is the heaviest component in the NAPU. It may vary from a minimum of 250 to 400 lb for an optimum vehicle arrangement with a radiation-resistant payload; to 500 to 600 lb for an optimum vehicle with a conventional transistorized payload; and to 1000 to 2000 lb for an inept vehicle-payload arrangement. Vehicle design will be simplified in most cases if this mass is located on the vehicle thrust line, although in some instances other heavy components in a vehicle may be used as counterbalances. This restriction will normally prevent location of the reactor-shield combination in the propulsion section of the vehicle, since tanks, pumps, and thrust chambers usually preclude center-line locations.

In general, two locations are of particular interest, although many variations are possible. The drawing below and on page 42 help to point out effects of vehicle arrangement. One shows a modular design with a payload nose cone, a cylindrical NAPU section, and a propulsion section. The other shows a NAPU nose-cone installation with a conical radiator, a payload section which may be initially nestled within the radiator, and a propulsion section. In either case the propulsion section may be jettisoned in orbit. Each of these systems has advantages and disadvantages.

Structural scatter of nuclear radiation emitting from the reactor can cause a high payload dose if shielding for the scattered radiation is not used. In the case of the modular design, with conventional transistorized payloads and no separation of the payload section from the remainder of the vehicle, the shield weight will be 500 lb or greater, depending on the payload frontal area. However, if a radiation-resistant payload is used, for example, one utilizing hard tubes or especially selected transistors in circuits which are tolerant of noise and component

SNAP-2 MODULAR CONCEPT



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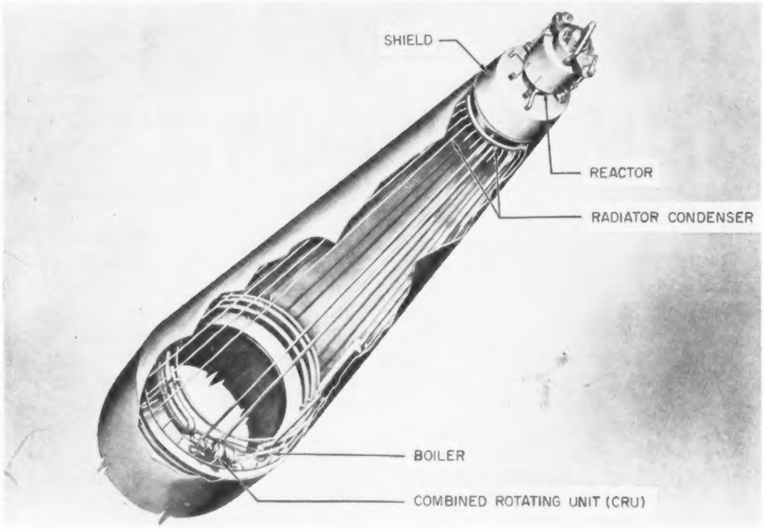
SNAP-2 NOSE-CONE CONCEPT



performance drifts, the required shield weight in this configuration may be only some 250 lb.

If the reactor is located in the vehicle nose and the nose-cone skin is jettisoned on the other hand, and if the payload is extended back below the radiator, an optimum shield results. The reactor and shield are on the vehicle thrust line and no structural scatter occurs since the entire vehicle-payload complex is within the shadow of the shield. With a conventional transistorized payload of any practical volume, the shield weight will be 250 to 300 lb.

This layout does introduce disadvantages, however. The APU is about 13 ft long instead of 7 ft, as in modular design. Of course, the possibility of nestling the payload within the radiator exists in this layout, whereas the modular layout precludes this. The NAPU access on the launch pad is better with the nose-cone location, but payload visual access in orbit may be much worse unless the propulsion system is jettisoned. Placing the reactor-shield combination at the tip of the vehicle increases gravitational restoring torques for satellite applications, but can perturb the vehicle flight stability. Re-entry burnup of the reactor is more easily obtained with the exposed nose location.

Payload tolerance affects the shield weight a great deal. It has been assumed that a conventional payload utilizing transistors can be subjected to 10^7 *r* of gammas and 10^{12} *nvt* of fast neutrons. A payload especially designed for NAPU's would utilize hard-vacuum tubes and radiation-resistant transistors in especially designed circuits which are tolerant of component drifts. Such a payload could be expected to withstand greater than 10^{11} *nvt* and 10^9 *r*.

Payloads extremely radiation sensitive, i.e., photographic film, should be equipped with individual shields so as to raise their tolerances to the payload design value.

Using Modular Concept

In general, the vehicle designer may find that the modular concept is easiest to integrate into the vehicle, but if weight is an important consideration he may have to provide special radiation-resistant payloads or utilize the nose location.

Van Allen and cosmic-radiation sources are usually no problem for unmanned systems. Exceptions occur in the case of photographic film and a few other very sensitive components. The yearly dose in the inner Van Allen belt (at about 2000 mi), taking in to account various geometric factors, fraction of time spent in the maximum dose rate region, etc., is about 10^5 *r*. That in the outer belt (about 13,000 mi) is somewhat higher but also more easily shielded. In either case, a great deal of attenuation can be obtained by use of the vehicle skin and other structural members as shielding, since the primary source of radiation consists of relatively easily attenuated electrons.

The requirements for manned applications depend heavily upon mission and upon the vehicle arrangement. If the mission is to spend most of its time in the Van Allen belts, the crew compartment will have to be well shielded, and as a result the reactor shielding need not be significantly different than for electronic missions. If Van Allen radiation is to be avoided, the crew-compartment shield will be quite light, and other steps must be taken to reduce reactor shielding. Normally, a configuration such as the illustration shown at left would be used with the crew compartment extended well to the rear of the NAPU. This not only provides the geometric r^2 reduction in dose rates but, more important, reduces the cone angle that the shadow shield must cover. The design is optimized when the incremental reduction in shield weight is offset by the incremental increase in telescope extension members and power-conductor weights.

If an established vehicle is modified for a NAPU, it may be necessary to conceal the radiator within the vehicle until orbit is reached, then ejecting the vehicle skin. This is brought about by the use of a specialized plastic or cellular skin. If the NAPU is integrated into the vehicle design early in the development, it would be possible to combine many of the functions of vehicle support, space radiation surface, and aerodynamic skin. A substantial weight reduction may be so gained.

The Snap radiator will operate at 600 F. It may thus be undesirable to have any payload components near by. In a configuration, such as the illustration above, a payload package may be carried to orbit nestled within the radiator and then extended to the rear before NAPU startup. This eliminates temperature interactions and significantly reduces shield weight.

Since a more reliable NAPU can be developed if it operates at constant electrical load and since induced torques are minimized under this condition, it is usually desirable to provide a dummy load control which insures a constant load to NAPU. It is necessary that payload transients be integrated into the design of the dummy load control, although serious interactions are not likely.

Alignments

In the case of an earth satellite, the axis of the CRU will normally establish the pitch axis of the vehicle. It may therefore be necessary to have a very accurate alignment between the CRU and the vehicle. Allowable deviations in vehicle attitude will be reflected as rpm tolerances on the CRU and as allowable torques resulting from other angular momenta in the vehicle. At low altitudes, it may be feasible to obtain attitude control from natural restoring torques and an oscillation damper. At very high orbital altitudes, a dynamic attitude control will probably be necessary. In that case,

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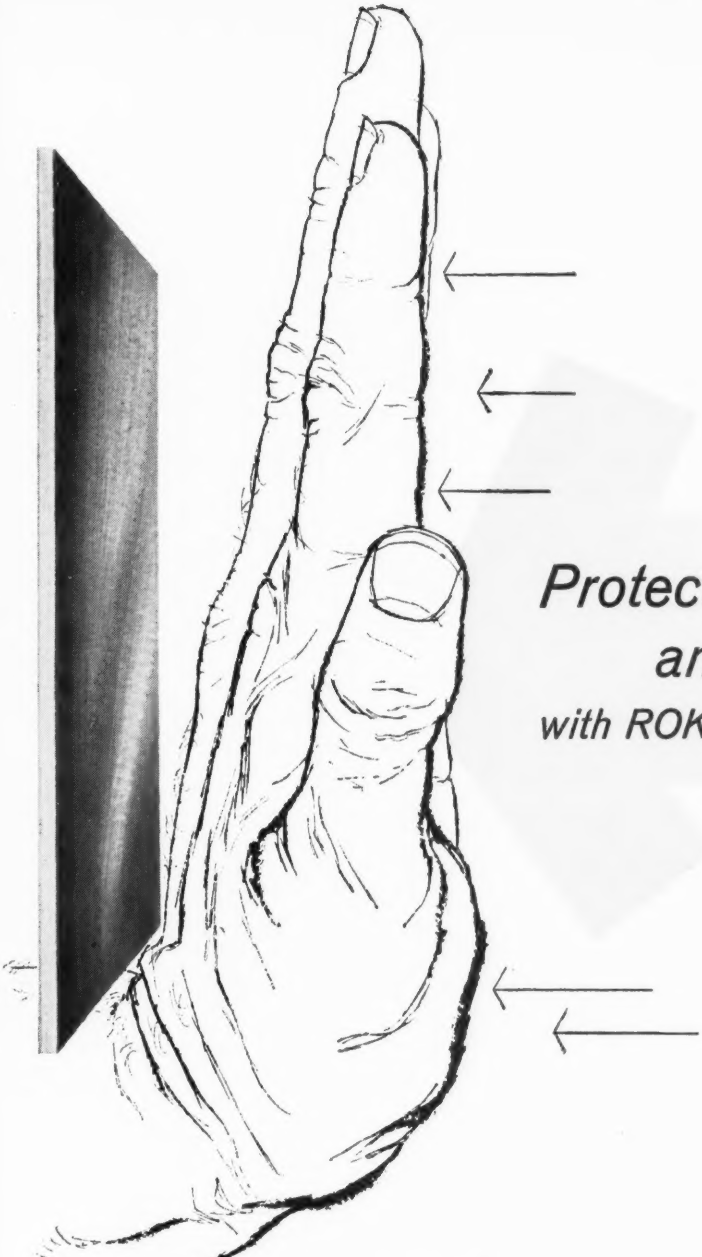

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a joint vehicle–APU study must be made to establish optimum induced-torque specifications to the NAPU supplier.

The Snap 2 with the CRU aligned to the vehicle pitch axis has the following characteristics influencing attitude stability:

Moment of inertia of CRU . . .	0.00072 ft-lb-sec^2
Roll-axis angular momentum . . .	< 0.01 ft-lb-sec
Pitch-axis angular momentum.	3.00 ft-lb-sec
Yaw-axis angular momentum . . .	< 0.20 ft-lb-sec

A frequency drift of 1 per cent corresponds to a torque of 9.7×10^{-10} ft-lb. A shaft acceleration of 1 radian/sec^2 corresponds to 7.2×10^{-4} ft-lb.

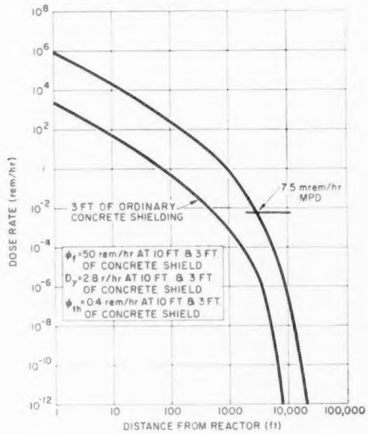
Ground-handling equipment and launch-complex modifications for the nuclear APU are extremely minor if orbital startup is utilized. Telemetry for the startup must be supplied. Straight forward "go-no-go" checkout instrumentation will be available. No nuclear checkout at the launch pad would necessarily be anticipated; this could be covered in an acceptance test procedure before delivery.

Nuclear Startups

If a pre-launch nuclear startup is desired, the system would be brought to power using a small, 50-kw electrical heater built into the primary coolant loop. The power-conversion equipment would be checked and the payload transferred to the NAPU. The reactor would be checked at very low power and then, just before launch, taken to full power as electrical heat is removed. If the mission is scrubbed, the NAPU or the entire final stage (depending on the separation provisions) must be placed in a shielded storage pit. A cleanup crew should also be available in case of a destructive booster abort.

RADIATION DOSAGE VS. DISTANCE

Full Reactor Power



The graph shown above depicts the dose rate during reactor operation. The permissible dose rate for 40-hr-per-week exposure is 7.5 mrem/hr. With a moderate amount of shielding, the blockhouse can be located within a few-hundred feet of the launch pad. Assuming that reactor operation may only be a few minutes per week, the unshielding exclusion need be only one or two thousand feet.

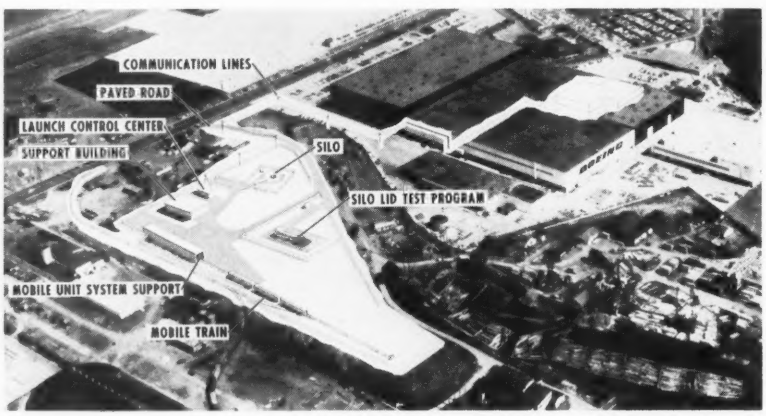
A nuclear ground startup complicates the APU development, testing, and launch pad handling. Safety exclusion radius must be provided and blockhouse shielding assured (both of these are usually covered by safety measures normally taken due to chemical booster hazards). In general, orbital startup provides the lowest cost NAPU in terms of APU development costs and launch facility costs, but with a sacrifice in reliability that may increase mission costs. Ground startup does provide 100 per cent checkout of the system prior to launch and hence may appreciably increase mission success probability.

A major goal of many missile designers today is the design of a completely indestructible re-entry body. The opposite is desired for Snap 2. Complete burnup of the reactor at extreme altitudes would effectively eliminate the re-entry hazards problems. Present plasma-arc investigations indicate that this objective can be met. It it necessary, however, that the vehicle designer keep this in mind and insure that the reactor is subjected to maximum re-entry heating.

The case of space problems and very high orbits (in excess of about 1000 mi) there is no re-entry problem since the reactor either does not return or ample time is available for fission product decay before it does return. If in these cases, the designer chooses orbital startup, the over-all hazards are essentially no different than they would have been if he had chosen any other power source.

The successful completion of the Snap-2 development will allow a new freedom in the choice of space missions. Adequate long-lived, reliable power will be available for most earth-satellite missions. Extreme-distance radio transmission will be feasible, allowing exploratory probes to the far reaches of the solar system. In addition, technology developed on this program is leading directly to NAPU's of other power levels for applications ranging from low-power weather satellites to high-power space vehicles with ion propulsion.

It is fully time for the mission analyst and vehicle designer to incorporate these NAPU's into their planning. Proper integration of missions, payloads, and vehicles with the NAPU's will make possible a new phase in space exploration. ♦♦



Developing the System

The retouched photo indicates the plan for the complete AF Minuteman launch complex being built by the missile system manager, Boeing Airplane Co., next to the Boeing Developmental Center in Seattle, Wash. The test complex will be used to determine the compatibility of all elements in the Minuteman weapon system. No missiles, of course, will be launched there.

120 KVA Electrical Power and Pneumatic Starting for Jet Aircraft . . .

This single AiResearch ground power package provides all the electrical and pneumatic power needed to meet the increased ground support requirements of the newest jet transports. At the same time, the new dual-purpose GPV-91 results in a unit that effects considerable dollar savings over separate units to provide pneumatic starting and electrical services.

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People in the news

APPOINTMENTS

Brig. Gen. Don Flickinger has been assigned staff supervisor for ARDC's bioastronautics research program, in addition to his duties as assistant for bioastronautics to Lt. Gen. B. A. Schriever, ARDC commander.

Henry Burlage Jr., formerly director, Propulsion and Aerodynamics Laboratory, Case Institute of Technology, has joined NASA as manager of advanced technology programs for liquid propellant rocket engines.

Kenneth S. Pitzer, professor of chemistry at Univ. of California, has been elected chairman of AEC's General Advisory Committee.

Milton U. Clauser, formerly vice-president and director, physical research laboratory, Space Technology Laboratories, has organized his own firm, Clauser Technology Corp., with headquarters at Torrance, Calif.

L. W. Warzecha, manager of advance space vehicle engineering at General Electric's Missile and Space Vehicle Dept., has been named project manager of the company's feasibility study group for Project Apollo; **E. J. Merrick** becomes project engineer. **J. Pieter deVries** has been appointed manager of astrodynamics for the space sciences laboratory, MSVD. **Benjamin G. Walker** will manage GE Defense Systems Dept.'s new Space Systems Operations, with headquarters in Santa Barbara, Calif.

William S. Stringham will supervise Martin Co.'s activities at Quehanna, Pa., where Martin plans to carry out advanced development work in the field of isotopic power.

Eugene J. Ziurys has joined Thompson Ramo Wooldridge Inc. as a consulting engineer in the Preliminary Design Dept. of Tapco Group's New Devices Laboratories. **Thomas M. Sullivan** will assume project management duties with the Group's Mechanical Product Development Dept.

George Sutherland, former head of Boeing's Advanced Propulsion Group, is now president of Rocket Research Corp., Seattle, Wash., a new company formed to conduct R&D and manufacture of rockets. **Robert M. Bridgforth,** former chief of Boeing's Propulsion Research Unit has been elected board chairman, and **Albert T. Parish,** also formerly with Boeing, becomes senior laboratory technician.

Joseph J. Hicks has joined the Instrument Div. of Beckman & Whitley Inc. as engineering manager.

R. L. McCreary, director of research, Collins Radio, has been named to direct the company's newly formed corporate research division to be headquartered in southern California and to do basic research in electronics.

Robert E. Moore will direct North American Aviation's new Quality, Reliability, and Standards technical division.

Jack H. Frailey, former manager of missile systems, RCA's Electronics and Control Div., has been appointed director of Itek Corp.'s Programs Div.

Charles K. Hersh has been promoted to senior engineer at Armour Research Foundation.

John Basarab Jr. has been named supervisory engineer, Shipboard Electronics Dept., Military Systems Div. of Lockheed Electronics Co. **Lewis C. Bohn,** authority in the field of international control of armaments, has joined the company's Systems Research Center.

Eugene Roberts will direct work at United Technology Corp.'s new Development Center near Morgan Hill, Calif., and will be assisted by **Aaron Rose.** **Stanley Warren** will head the Propellant Processing Branch; **Francis J. Lavacot,** Quality Control and Reliability; and **W. D. Van Patten,** will direct testing operations. **Phillip A. Peller** will head the Plant Engineering Branch of the firm.

Ryan Aeronautical's main plant operations in San Diego has been formed into a separate division, the Ryan San Diego Div., with **Edward G. Uhl,** vice-president and division manager, in charge. **Frank W. Fink** and **H. E. Ryker** have been named vice-president, engineering and manufacturing, respectively.

Irving Weiman has been named associate division manager, Solid State Div., Electro-Optical Systems, Inc. **Henry L. Richter Jr.** will manage EOS' newly formed Advanced Electronics and Information Systems Div. Dr. Richter was chief of the space instruments section, Space Sciences Div. of JPL. **Myer Geller** has joined EOS as senior scientist in the Solid State Div., and **Henry H. Hilton,** as senior physicist in the Fluid Physics Div.

James R. Weiner has been named vice-president, engineering, Philco Corp.'s Government and Industrial Group, and **Louis R. Lavine,** manager, programming research and development, Computer Div. of the Group. **Lawton M. Hartman** becomes associate director of research, operations, of the firm.

William E. Diefenderfer has been appointed assistant general manager of Hamilton Standard. **Harry E. Gravlin** becomes operations manager and **Donald G. Richards** engineering manager, succeeding Diefenderfer. **Charles F. Squire** has been named divisional director of research of the company's new scientific laboratory. Dr. Squire was professor of physics and director of research at Rice Univ.

Jerry Gabriel has been appointed director, long range market and product planning, Jack & Heintz, Inc.

HONORS

Robert W. Bass, chief scientist for Aeronca Mfg. Corp.'s Aerospace Div., Baltimore, Md., was recently named Maryland's outstanding young scientist of 1960 by the Maryland Academy of Sciences for which he received a plaque and a check for $500. ◆◆

Clauser

Walker

Ziurys

Sutherland

Hicks

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Bomarc B motors produced at the Utah Division

In print

Systems Preliminary Design, Principles of Guided Missile Design, by Joseph J. Jerger; D. Van Nostrand Company, Princeton, N.J., 1960; 625 pp., Illustrated, $14.75.

There is much value in trying to put inside one volume all that is known and achieved in one field, but in a rapidly advancing art like the guided-missile business summaries such as this one are doomed to be quickly outdated. This book does not help the journeyman or the student to draw the much-needed generalities and essences out of the many long lists of parameters running through its pages, a service which could have extended its life.

Jerger's classification of missiles into (a) surface-to-surface, (b) surface-to-air, (c) air-to-air, (d) air-to-surface is a case in point, and illustrates how official organization charts and newspaper politics have beclouded the issues. Simple technical categories, such as (a) fixed launch platform and target and (b) mobile launch platform and/or target, would be much closer to the technical problems facing the engineer and incidentally would cover missiles in all media. (One notes that the first guided missile, still important, is not mentioned in this book on guided missiles, namely, the torpedo.)

Similar criticism can be leveled at Jerger's classification of 10 missile systems. Three main categories—such as (a) stored command (self-reliant after launch), (b) remote command (instructed during flight), and (c) target command (homing)—would be much more manageable for the first breakdown and would give the student the essence of the problem to commit to memory.

The voluminous items listed are presented as if each were a problem for the missile engineer to solve. It would be better for the engineer, the Defense Dept., and the taxpayer's pocketbook if they were presented as problems that the engineer is encouraged to eliminate *not* solve. Example: "Maintenance of an active state of readiness demands an excellent system of missile storage, preparation, checkout, and launch." Acceptance of this notion as a basic policy has cost the nation untold millions of dollars. In the few instances where the reverse was adopted as a primary premise (e.g., eliminate maintenance, preparation, checkout, etc.) enormous dividends have been achieved in reliability and cheapness.

The author quite often ignores reality. He says, for instance, "The ability of a system to adapt itself to various tactical assignments is highly desirable in that it provides a maximum of service with the least complication and cost." The history of this practice has shown, in many cases, that the total complexity and cost of a small number of weapons may very well be greater than for a large number each designated for specific usage.

The chapter on reliability is useful as far as it goes, but there is no discussion of the newer theories of small-sample testing or sequential testing, which could, we hope, bring economies to the destructive tests our monstrously complicated and expensive missiles must undergo. If the author has rejected these theories he should say why.

The chapter on guidance and control design is the key to the general approach. It is a good introduction to a number of standard practices used in the business, but it does not really suggest or point out the new problems already identified in the guidance game. I do not know whether the author was hampered by security regulations, but it seems to me that for one who has specialized in air-to-air missiles to omit even a theoretical discussion of torque-balance versus fixed-gain controls is almost unforgivable.

The paragraph on nonlinearities also misses the target. Here was a marvelous opportunity to discuss extensively the true nature of the beast—that we have reason to believe nonlinearities really predominate in nature; that if we do not disarm ourselves by pursuing only the notions that are susceptible to analysis, out of worship for sophistication, we may, on occasion, fall heir to legacies waiting to be uncovered in the nonlinear world; and that, having only the grossest analytical tools for such subtleties, we must resort to empirical means to discover them.

For one who wants a "cookbook" exposition of how things *have* been done in the guided missile game, this book will serve the purpose. Perhaps the best practical use of the large amount of material in it, is as an exercise source for a newcomer to the field, provided his tutor knows enough to place values on the methodology described. The book could have had more usefulness and a longer life if it approached the subject in a more fundamental way.

—Bernard Smith
U. S. Naval War College

BOOK NOTES

In **"IGY: Year of Discovery"** (Univ. of Michigan Press, 112 pp., $4.95), Sydney Chapman, internationally known physicist, has written *the* story of IGY for the layman. In a handsome, large-format volume replete with a flock of first-rate illustrations, Prof. Chapman, known as "the father of the IGY" for his work as president of the international committee of scientists which directed IGY, reviews what we have already learned about the earth and the oceans, the upper atmosphere and space, and what we hoped to learn through the combined efforts of the 67 nations which participated in the effort. In his introduction, James Van Allen says the book "will engage the attention of every person who has an interest in the natural phenomena of the world in which he lives." For once, we can second the motion.

In **"Man into Space"** (paperback, 144 pp., $0.75 and inexplicably published in Fawcett's "How-To" series), Lloyd Mallan continues his low-priced, cut-and-paste, popular exploration of astronautics. Still stubbornly sticking to his belief that the Soviet space program is a myth, Mallan here confines himself entirely to U.S. man-in-space efforts, while dipping into other important experiments as well. Subjects covered include the role of NASA, the Able-Baker flight, Atlas-Score, the Discoverer program, Pioneer IV, the X-15, and the Mercury Astronauts. A brief introduction to rocketry and astronautics, mistakenly labeled "A Career in Astronautics," fills out the volume. As always, Mallan has rounded up an impressive collection of illustrations to go with the text.

Scientists and engineers anxious to keep up to date on modern physics will find a new textbook by Robert Resnick and David Halliday of considerable interest. Called, appropriately enough, **"Physics for Students of Science and Engineering, Part 1"** (600 pp., John Wiley, $6.00), it starts with physical measurement, and proceeds through vectors, motion, particle dynamics, work and energy, gravitation, fluid dynamics and sound waves, and goes all the way to the kinetic theory of gases. Problems (and answers) and a series of helpful appendices are additional extras. Part 2 will cover electromagnetism, optics, and quantum physics. ♦♦

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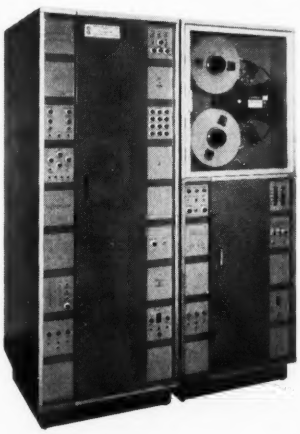

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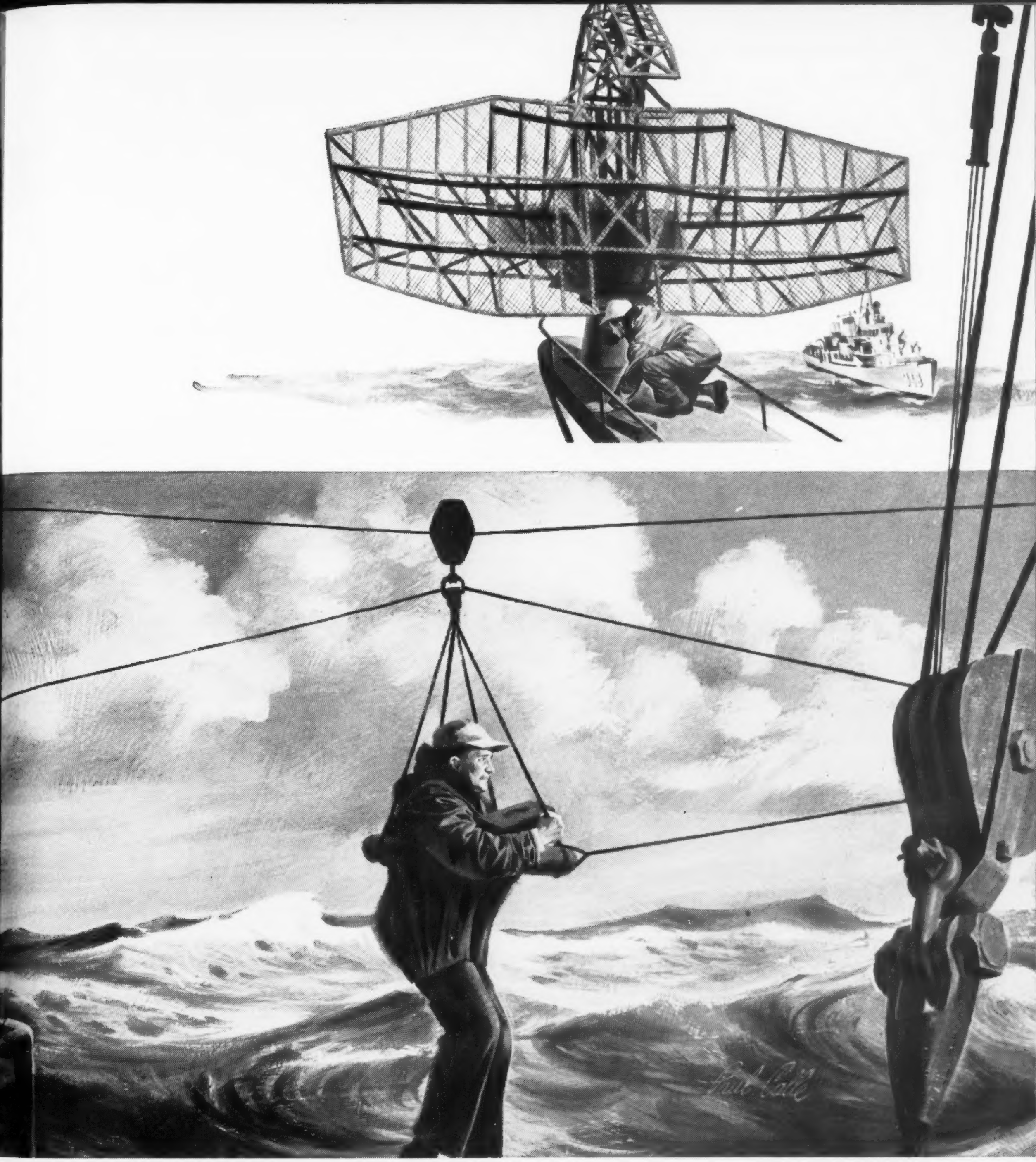

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Operational Concepts

(CONTINUED FROM PAGE 29)

by the missile, but by the operational intent of the military services regarding the employment of the missile operationally.

The setting of early operational dates, and consequent foreshortening of development time, has forced into existence the policy of *concurrency*—the parallel, concurrent development of all portions of a weapon system. If concurrency is to be followed, however, it must be followed from the start of the developmental program. The missile must be thought of as just one of the subsystems of the weapon system, all of which should be specified in the over-all design phase of the weapon system. Development in each area should then proceed in parallel with all other phases.

What makes up a weapon system? For our purposes, the weapon system will consist of the missile and all of the required equipment and support which will permit the missile to meet prescribed reliability, accuracy, and availability requirements for the purpose of carrying a payload to the target.

It can be seen that the weapon system is made up of the missile and many other subsystems. The *missile*, in turn, is made up of a group of general subsystems, which are made up of further subsystems and components. All other subsystems may similarly be subdivided. Further inspection will show that the missile subsystem is all of the weapon system that flies. *All the rest are support systems.*

In this discussion, we shall be concerned with *operational* ground-support systems and the effects of operational concepts on their design, rather than any test or R&D support systems. It should be made clear that operational support systems are not *only* the hardware like ground-operating and ground-support equipment, but also nonphysical things like maintenance, logistics, training, manuals, and many other.

It becomes more and more evident that these phases of the weapon system must be given more emphasis. Just because a missile is flyable, does not mean that an operational weapon system exists; for only when the other 85 per cent of the weapon system is designed, developed, fabricated and in the field, and men trained, is there such a thing as an operational weapon system.

Most of the readers will be able, with a minimum of thought, to break down the subsystems listed in the diagram on page 29 into smaller subsystems. Each of the blocks is broken into many smaller systems, as is shown for the missile. In order to complete the thought, the table at left indicates the type of equipment and services involved in each of the major weapon subsystems, plus a reason for the division of the system selected here. All subsystems are included in this table except system management, which has a unique position with respect to the weapon system. Items such as cost, schedules, and reliability could well be overriding parameters of the entire system—absolute requirements for the successful attainment of any goal.

Analysis of Major Weapon Subsystems

Subsystem	Typical Equipment and Services	Comment
Ground-Operating Equipment	Launch-Control Equipment	All equipment needed to launch missile, but which does not fly
	Launch Consoles	
	Ground Electric Hydraulic and Pressurization Systems	
	Power	
	Propellant Loading System	
Ground-Support Equipment	Mobile Maintenance Equipment	Equipment needed to test, handle, maintain, repair, checkout, calibrate missile and GOE
	Squadron Fixed Maintenance	
	Component Test Equipment	
	Missile Handling	
	Propellant Handling	
	Pressurant Tankers	
	Cranes	
Personnel	Training	
	Individual Integrated	ATC bases
	Weapon System, Training (IWST)	Spec. bases at squadrons
	On-the-job Training (OJT)	" " " "
	Manning	Minimized number of personnel in squadron
Manuals	Function Manuals	Requires electronic data processing for scheduling and up dating manuals
	Equipment Manuals	
	Job-Oriented Manuals	
	Inspection Manuals	
	Maintenance Manuals	
	Training Manuals	
Maintenance	Air Force Policies	Major occupation of operational squadrons
	Equipment	
	Personnel	
Logistics	Initial Stocks	EDPS center of activities
	Spares	
	Supplies and Stock	
Facilities	Operational	Protect missile and GOE
	Launcher	
	Blockhouse	
	Support	
	Security	Contain or aid ground-support equipment
	Support Base Housing	
	Roads	
	Maintenance Bldgs	
	Munitions Buildings	
Communications	Essential	Direct from SAC to squadron
	Launch Enable System	
	SOCS	
	P.A.S.	
	Support	
	Telephone Network	
	Microwave	Intra-squadron
	PA System	

Some Economics

Costs are important, both in terms of the operational squadron and the development program. Development programs for major ICBM's cost in the order of two or more billions of dollars. Operational squadrons can cost from \$100–200 million each initially, and \$10–20 million a year to operate. Because of the widespread array of contractors used in developing a weapon system, small initial errors can multiply costs immensely. Poor control of quality in manufacture or construction of any one subsystem can cause development costs in all systems to increase by millions of dollars. All development programs (and all should have as a major goal the design of the most practical system with respect to the operational requirements) must use the *ultimate* costs of the various designs of *operational* squadrons as one of the parameters in deciding among alternative squadron designs.

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The time at which the missile becomes operational is a time set arbitrarily by the customer, as a part of the operational requirement. This time can be extremely short. Thus, the schedule has a tremendous effect on the type and level of development of equipment, procedures, and the methods used in a squadron; the kind of facilities; the kind of operating equipment; and the missile itself. The short time allowed for development embodies the principle of concurrency and thus runs the danger of considerably more risks than a sequential development program.

Reliability is an ally of costs and schedules, and it is also a function of costs and schedules. Reaching a higher level of reliability costs more money. On the other hand, if the missile is less reliable, more missiles are necessary to perform the mission. The selection of the optimum level of reliability is of paramount importance. The level to be attained is a function of time. It may take just a short time, comparatively, to reach 80 or 90 per cent reliability but an infinitely longer time to get to 99 per cent reliability. The important point to understand about reliability, however, is to know its *exact* value at whatever level is attained, rather than to strive for the highest possible level.

In the attaining of any weapon system, this path is usually followed: Operational requirements, operational concepts, design concepts, operational weapon system. Operational requirements are developed by the military services. They are usually rather broad, and deliberately so, because they are intended to present the fundamental desires of a service, rather than detailed concepts. At the time operational requirements are formulated, all that may be known of the weapon system might be that it must deliver a certain accuracy, and obtain a specified number of impacts on the enemy target.

From each operational requirement develops much more detailed demands upon the system, called operational concepts. Once the operational concepts are set up, design concepts can be developed so that the physical system will meet the operational concepts. There are many ways to attain any specific operational concept. From this point to obtaining an operational weapon system is a long, hard, arduous battle, with a lot of feedback occurring among design concepts and operational concepts and requirements and back again to the operational weapon system.

Operational concepts, we have said, are more detailed than the operational requirements. For example, important in the number of impacts on the enemy target system is the number of missiles surviving a prior enemy attack. Survivability is determined by the hardness of a site and the dispersal of a number of sites. *Hardness* is the overpressure which the entire weapon system must be able to withstand and still be able to launch the the missile at the enemy after an attack by a nuclear blast. *Dispersal* is defined as just how far apart sites must be put in order to prevent a multiple destruction of sites by a single enemy warhead. These two together make for survivability. Survivability is a very important parameter, which hasn't received much emphasis until lately. It is not the established inventory of missiles in a guided missile force which is important, it is how many will be available after an enemy attack, for there is a high probability in the attitude of our country toward war that bases will be struck before they will be able to launch missiles.

In addition to survivability, there are a number of other concepts which permit the attaining of operational requirements.

The Reaction-Time Factor

Reaction time is the time required in order to launch a missile, dated from the time the order occurred, and can be anywhere from two minutes to two hours. It is merely the time from the instant someone *says* "push the button" until the missile is actually launched.

Also, how much protecting the weapon system—against internal hazards (the explosion of its own missile, fire toxicity of propellants, etc), against ordinary climatic conditions, and against the effects of nuclear attack in terms of thermal effects, nuclear radiation, blast overpressure, debris, and fallout—is required to permit the missile to be launched at any time?

It must be determined how and at what levels all of the missiles must be kept to meet a certain specified countdown at the signal "GO." For example, it might be required to launch as many missiles as possible, immediately, as a salvo. This is ultimate readiness, where only reaction time stands between the order and its execution. But there are a number of states of readiness in which the missiles can be kept in terms of time—from ultimate readiness to storage of missiles in a depot, where days would be required to ready them for launching.

Squadron configuration means simply, what kind of a squadron is desired? What is the physical arrangement of a squadron? Is it desired to have a launcher off by itself, or to have a group of them together at one spot?

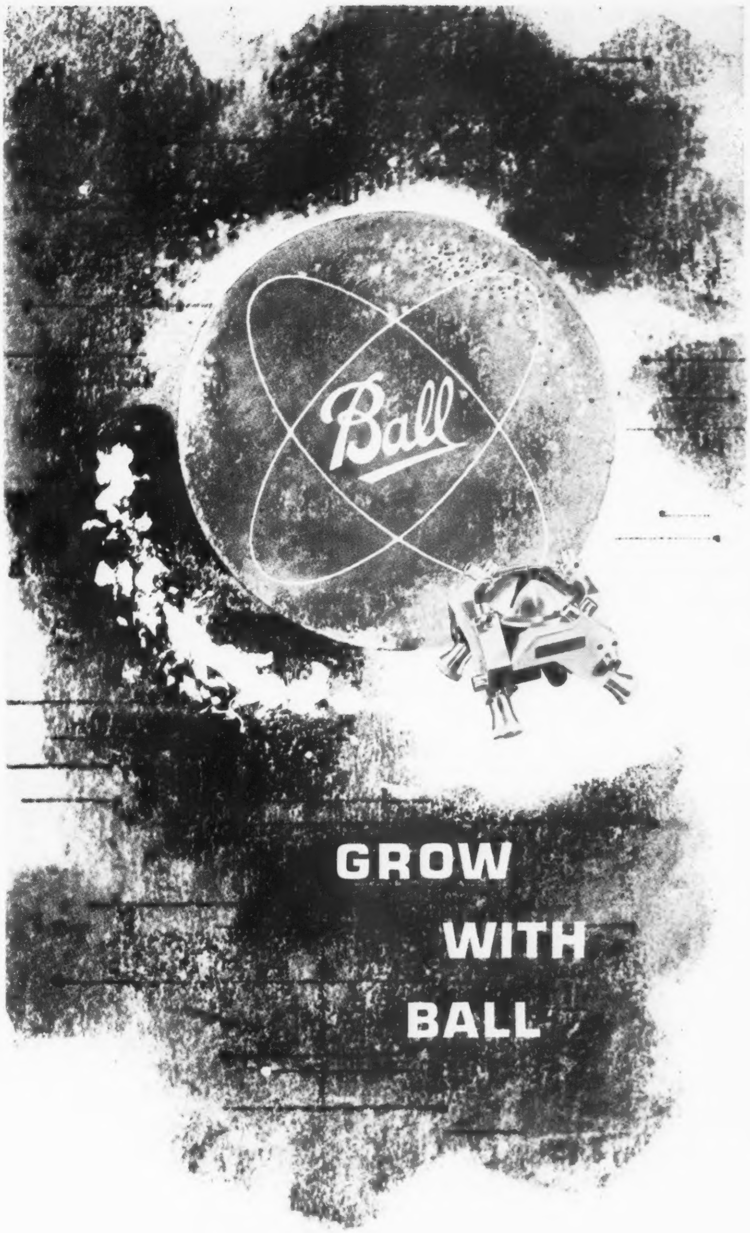
Of course, there are many other considerations involved with this. The fundamental reason for being interested is the independence requirement. What is the level of independence? Is it required that the launchers be independent of the surrounding environment for any specified length of time, or is it the lesser requirement involving the independence of a squadron of launchers? If a *launcher* is specified to be independent, then it must be independent of what—of cryogenics, of crew-shift changes, of maintenance? All such things have a big effect on design of facilities, number of people, or type of equipment.

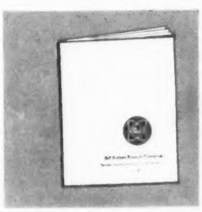
There exists a logical sequence which finally results in the placing of an operational weapon system in the field. The diagram on page 29 shows what might be called a *weapon system cycle*. There are many ways of depicting such a cycle. Time is not specifically indicated here. The time scale to go from the operational requirements and concepts to operational use might be as much as 10 years or as little as two years.

Prior to operational requirements, we must have a situation in the world—military, economic, and political—which will demand that such operational requirements exist. As an example, consider just one political situation, the posture of the U.S., or any democracy, in the whole power-politics situation: *A democracy will not start a war.*

If the democratic principle in the Cold War, based upon moral and spiritual considerations, is not to start a war, then it is necessary to put in the hands of the nation a means of deterring aggression; a capability of retaliating against enemy attack, so that the enemy will know that even if he strikes, frightful destruction can be vented upon his country. In the present world situation, only then can this nation continue to exist. However, we must let ourselves be hit first. This is a rather horrifying beauty of a democracy.

In order to see the effect of this political policy on weapon system design, consider what would occur if the policy of deterrence *didn't* exist— if a nation *could* initiate a war. In the first place, missiles would not have to be maintained at the ready at all times at the highest possible level. It would not be necessary to maintain men, cryogenics, equipment, and, indeed, the whole system at the highest possible state of continual readiness, which requires a very complicated system at a very high cost. A very much simpler system, although longer acting, would suffice to launch the missile. This is because the time of





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attack could be selected, and the missiles brought to ultimate readiness at leisure. In most instances, the automation and complexity required by the extremely short reaction time would not be required, nor would the high level of reliability of missiles. Missile forces could be built to the proper size for the job, and no more. It would be necessary to ascertain the length of time to bring the major portion of missiles to launching condition. Much less equipment, much less reliable missiles, less automaticity in the ground equipment, less requirement for spares, no requirement for fast propellant-loading systems, and no requirement for hardened facilities or independence of launchers—all of which are of a very high cost and must exist in the deterrent posture—would be required. The main point is that military, political, and economic situations in this world dictate the operational requirements, and through them the design of the system.

Once the operational requirements for a weapon system have been firmed, the Air Force asks teams of companies to submit design studies which will fit the operational requirements which they have stipulated. The teams will submit proposals based upon different sets of operational concepts, all of which have been based upon the same operational requirements.

One team is ultimately selected, and that team will then perform the detailed weapon system design. This is where the operational concepts may be changed to some very great degree when balanced against design capabilities and problems, and where the design concepts are developed in detail.

Subsystem Origin

From this point, and almost immediately on a parallel basis, all of the subsystem development program originates. The subsystems are all of those defined in the diagram on page 29. There is a third dimension then in the subsystem, area, shown by the diagram on page 29, to accommodate all subsystems, each one of them going through the various phases: Preliminary design and development, preliminary flight rating tests, prototype tests, qualification, and reliability testing.

Ultimately, all of the hardware subsystems are brought together at operational systems test facilities (OSTF). Some of the other operational subsystems, such as logistics, maintenance, and personnel, probably will never be introduced until the installation and checkout of the operational site. But all of the other things—the GOE, the GSE, the propellant-loading system, the launcher, etc.—are brought together. The contractors will test the missile and all of the associated equipment under as many of the operating conditions as possible, and finally arrive at a prototype system. The prototype system will be somewhat at variance with the original idea and with the original concepts coming out of the subsystem area, because the interactions between the various subsystems of the weapon system first come to light during this assembly and test phase. So a feedback occurs. There will be a redesign and a cycle is set up so that the prototype eventually will change.

The system is then turned over to the Air Force. The Air Force will perform its own military testing, after which it will authorize full production of the missile and its equipment. Once production has been authorized, construction of sites will be authorized; and as production proceeds, and missiles and equipment leave the production lines, there will be indoctrinary weapon-system training. The training is so scheduled—as is production—that when one has finished constructing the site, the equipment and personnel are ready to go into it. The system will then be put into operational use, mainly for peace as a deterrent, and for war if necessary.

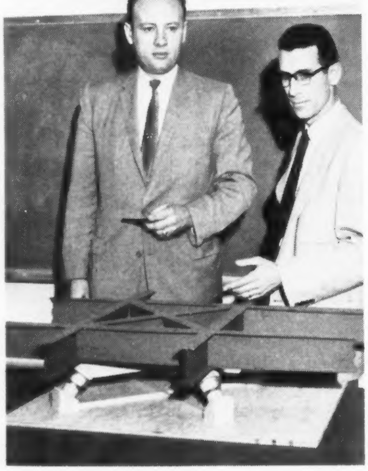
Each of the phases, after subsystem development, will feed back changes—engineering changes—to the subsystem development area, which will then follow change-order procedures back through assembly, test, proofout, prototype, production, training, and so on, back into operational use. However, any idea which requires a very gross redesign should *not* be fed back through a subsystem development phase, but should be pooled into the new idea area, as indicated by the diagram on page 29. The new ideas should feed to one of the phases *prior* to the subsystem development which should then initiate a whole new weapon system, still fulfilling operational concepts. It is not proper to feed *major* idea changes back to the subsystem development area, simply because major ideas are *changes* in philosophy, not just *correction* in philosophy. Major changes fed back through the subsystem phase, would result in the "same" weapon system having as many as four or five operational configurations. Thus, there remains an excellent chance of violating the basic concept under which the original weapon system was designed, ruining any chance of attaining operational status *in time*.

It is neither possible nor proper to ask one weapon system to fill all possible needs and desires. The more demanded on any one system, the more costly will it become in time, money, materials, and men.

The Cycle in Theory

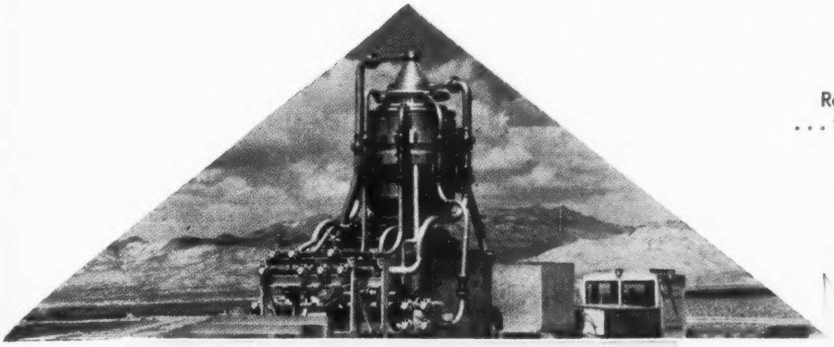
The cycle shown diagrammatically on page 29 is theoretical. It would be fine if such a program could be followed. As a matter of fact, those in the missile business would like such a program—the sequential development of qualified subsystems before assembling and testing them, before turning them into prototypes, before producing, before constructing facilities, and so on to operational use. This actually does not and cannot happen. So far as most weapons systems are concerned, the time allowed for getting them into operational use is determined not by what *can* be done technically, in the best sense, but by what *must* be done to maintain a certain military posture in world politics. It is necessary to optimize—to obtain the best possible weapon system within the time limits indicated by the military and political leaders of our country. The best weapon system is of very little use if it is obsolete when it becomes operational. ♦♦

Giant "Rock and Roll"



Engineers K. P. Buchert and Llewellyn Kazebee of U.S. Steel's Consolidated Western Steel Div. show model of an inertia-measuring platform the firm is designing and will erect for the Air Force at Edwards AFB. The huge cruciform platform will put ballistic missiles or aircraft weighing up to 300,000 lb through pitch, roll, and yaw motions. The concept and the initial study of the platform was the work of Cornell Aeronautical Laboratory, which is developing the necessary instrumentation.

AT THE CONTROLS on three new frontiers . . .



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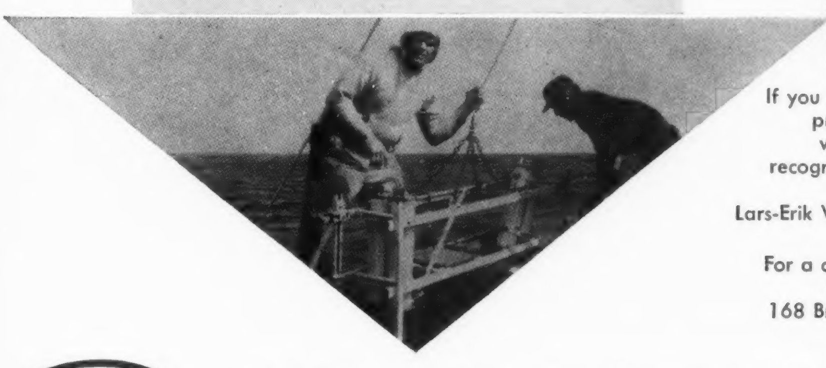

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ARS news

Dayton Meeting Promotes Research in Bioastronautics

Proposed research in biological and biomedical science by individuals in companies or public institutions has an excellent opportunity for support through any of several federal agencies. This was the message of the panel on Government Grants and Contracts, which supplied a good part of the interest of the recent Anatomy of Manned Space Operations Conference, held Oct. 10–12, 1960, in the Dayton Biltmore, at Dayton, Ohio, under the auspices of the ARS Human Factors and Bioastronautics Committee in cooperation with the Aerospace Medical Laboratory and Office of the Surgeon, AMC, Wright-Patterson AFB, and the ARS Dayton Section.

The joint statements of the members of this panel are now available from ARS Headquarters at a cost of $2.00 per copy. The researcher seeking support for his ideas or projects would be advised to obtain and study these statements, for they spell out the right way to approach the agencies involved. These agencies and the individuals representing them are listed under the picture of the panel shown here.

The Conference on Anatomy of Manned Space Operations brought this panel together to discuss government grants and contracts for research in the life sciences: From left, John M. Talbot, Dept. of Defense, Washington, D.C.; Ernest M. Allen, National Institutes of Health, Washington, D.C.; Sidney Galler, Office of Naval Research, Washington, D.C.; Albert W. Hetherington, Andrews Air Force Base, Washington, D.C.; Freeman H. Quimby, NASA, Washington, D.C.; Lt. Col. Richard R. Taylor, Army Research and Development Command, Washington, D.C.; and Max R. Zelle, AEC, Washington, D.C. Their discussions, bound as a single report, are available from ARS Headquarters in New York for $2.00 per copy (see box on page 64).

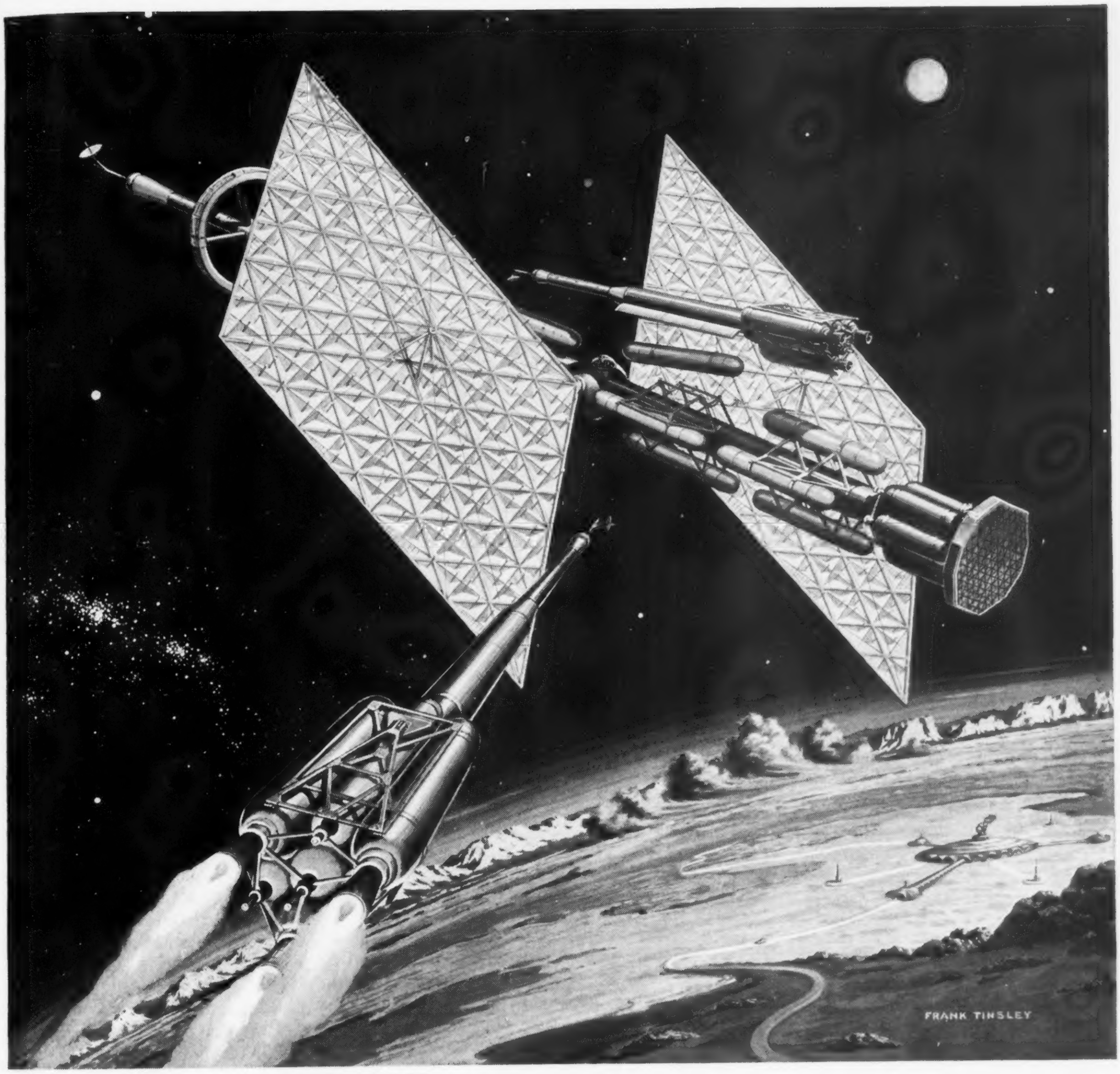
It is a good thing that the transcribed comments of this panel are available, for the conference was not well attended, and it was clear from even its limited program of papers on anthropometrics, bio-instrumentation, and human factors, and comments from the short panel on bionics, that the man-machine system for space flight, and all that impinges on it in the nature of medicine, biology, physiology, and the like, represents a scarcely tapped field of basic and applied research, much less advanced engineering.

The opening session introduced anthropometric data which indicate that the American man is getting taller and heavier ("Heights and Weights of White Americans," by Stoudt, Damon, and McFarland, ARS Preprint 1351-60; "The Body Size of Tomorrow's Young Men," by R. W. Newman, ARS Preprint 1352-60). This data should be of long-term interest to space-cabin and -suit designers, and more literature should be forthcoming.

1960-61 ARS Meeting Schedule

Date	Meeting	Location	Abstract Deadline
Dec. 5–8	ARS Annual Meeting and Astronautical Exposition	Washington, D.C.	Past
1961			
Feb. 1–3	Solid Propellant Rocket Conference	Salt Lake City, Utah	Past
March 13–16	Missile and Space Vehicle Testing Conference	Los Angeles, Calif.	Past
April 5–7	Lifting Re-entry Vehicles: Structures, Materials, and Design Conference	Palm Springs, Calif.	Past
April 26–28	Propellants, Combustion, and Liquid Rockets Conference	Palm Beach, Fla.	Past
May 22–24	National Telemetering Conference	Chicago, Ill.	Dec. 15
June 14–17	ARS Semi-Annual Meeting	Los Angeles, Calif.	Feb. 1
Aug. 21–23	International Hypersonics Conference	Cambridge, Mass.	Jan. 15
Aug. 23–25	Biennial Gas Dynamics Symposium	Evanston, Ill.	Jan. 15
Oct. 9–13	ARS SPACE FLIGHT REPORT TO THE NATION	New York, N.Y.	May 2

Send all abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.



STEPS IN THE RACE TO OUTER SPACE

Mars Supply Fleet

When man first sets up colonies on Mars, his life will depend on a Mars Supply Fleet, shuttling from Earth at regular intervals with supplies, equipment and personnel.

The fleet will be comprised of two basic vehicle types, both shown in the illustration above. The large ships with rectangular solar reflectors will be the long-range backbone of the fleet. Assembled in orbit of prefabricated sections rocketed up from Earth, these high-capacity carriers will have a low-thrust electro-particle drive. Their operating current will come from thermionic converters, heated by the concentrated rays of the reflectors.

The Solar Ships will be loaded and unloaded, at both ends of the voyage, by work-horse Ferry Rockets (foreground) launched by booster. The ferries will be designed to carry the long yellow cargo containers within a bay just forward of their engines. In the nose of the Ferry Rocket is the passenger and operating section with a universally mounted spherical guidance compartment. This guidance unit will be fitted with directional radar, an optical telescope, and full astrogational equipment.

The Mars Supply Fleet will complete each assigned mission in one to two Earth years, depending on whether or not the Solar Ships are equipped with auxiliary boosters for extra initial speed.

ARMA, now providing all-inertial guidance systems for later models of the Air Force ATLAS ICBM, is in the vanguard of the race to outer space. At **ARMA**, privately funded research programs in space technology are studying super-sensitive inertial devices for navigation and satellite instrumentation. For this effort, **ARMA** seeks scientists and engineers experienced in astronautics. **ARMA**, Garden City, New York. A Division of American Bosch Arma Corporation.

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The second session, on bio-instrumentation, suggested that both engineers and scientists have a long way to go in preparing man for other than short-duration orbital flights. Co-chairman of the session, Ralph W. Stacy of Ohio State Univ., made the introductory remark that "preparations for manned space flight are premature," and offered the opinion that the criteria for determining the condition of the astronaut have yet to be established. Samuel A. Talbot of Johns Hopkins School of Medicine, giving the first of three papers in the session, "Instrumentation Needed for Manned Space Flight" (ARS Preprint 1358-60), stressed the need to develop related standards and instruments for monitoring the *psychological* condition of the astronaut beyond what would be called the "normal." This is virtually virgin ground for study. Capt. George Potor Jr., USAF, of the Aerospace Medical Laboratory at Wright-Patterson, in his paper "Currently Available Instruments Applicable to Manned Space Flight" (ARS Preprint 1359-60), concluded that "instruments and methods for measuring man's physiological parameters and those conditions in his environment most essential to his well-being have not kept pace with requirements or with the potential of the electronic art"; and his concern was chiefly with nominal physiological measurements associated with aviation medicine. Robert Yereance of Battelle Memorial Institute, in the last paper of the session, pointed again to the stringent reliability requirements required of instruments for space flight (ARS Preprint 1360-60). Their comments taken together point to a long and difficult development period for space medical equipment, and at the same time one full of surprises and new ideas. Mention was made of testing promising instruments brought forward in the years to come in the manned orbital laboratory planned by NASA for late in this decade.

The bionics panel, consisting of Otto Schmidt of the Univ. of Minnesota, Lt. Col. Jack Steele of AML, and E. B. Johnson of ITT Communication Systems, Paramus, N.J., ranged over the now widely discussed possibility of tapping Nature's designs for machine applications and data processing. Dr. Johnson presented an interesting review of the state of the art in cybernetics. Time and again the panel members mentioned the need for bringing good people from the appropriate fields together in a working situation for mutual education in this area.

The human factors session was devoted chiefly to some discussion of a big indeterminant in space operations—the chap with stubby fingers back on the ground, his oversights and fumbles. This session suggested the need for a major meeting on combined ground and space operations as soon as the flight tests of the X-15 and the Mercury capsule produce a body of results.

The luncheons and banquet featured excellent speakers—Capt. Joseph W. Kittinger Jr., USAF, of the Aerospace Medical Lab, who at the first luncheon recounted his experiences in the Excelsior-III balloon jump from above 100,000-ft altitude, and argued for conditioning astronauts for space flight with balloon hops; William F. Ashe of Ohio State Univ. Medical College, who in the second luncheon reviewed his University's progress in providing a modern curricula for the M.D.'s specializing in space medicine and associated engineering; and Douglas Talbot, Cardiac Consultant to WADD, who at the banquet gave a masterful picture of the relation of studies on cardiovascular response and arteriosclerosis to space medicine. Among other things, Dr. Talbot reported that a beginning has been made

On the calendar

1960	
Dec. 5–8	**ARS Annual Meeting and Astronautical Exposition, Shoreham Hotel, Washington, D.C.**
Dec. 13–15	Annual Eastern Joint Computer Conference, Hotel New Yorker and Manhattan Center, New York, N.Y.
1961	
Jan. 9–11	National Symposium on Reliability and Quality Control, co-sponsored by IRE, AIEE, ASQC, EIA, Bellevue-Stratford Hotel, Philadelphia, Pa.
Jan. 16–18	AAS Annual Meeting & Exhibit, Sheraton Hotel, Dallas, Tex.
Feb. 1–3	**ARS Solid Propellant Rocket Conference, Hotel Utah, Salt Lake City, Utah.**
March 9–10	Symposium on Engineering Aspects of Magnetohydrodynamics, sponsored by AIEE, IAS, and IRE, Univ. of Pennyslvania, Philadelphia, Pa.
March 13–16	**ARS Missile and Space Vehicle Testing Conference, Biltmore Hotel, Los Angeles.**
April 4–6	Symposium on Electromagnetics and Fluid Dynamics of Gaseous Plasma, co-sponsored by Polytechnic Institute of Brooklyn, IRE, IAS, and U.S. Defense Research Agencies, Engineering Societies Building, New York, N.Y.
April 5–7	**ARS Conference on Lifting Re-entry Vehicles: Structures, Materials, and Design, El Mirador Hotel, Palm Springs, Calif.**
April 18–20	Symposium on Chemical Reaction in Lower and Upper Atmospheres, sponsored by Stanford Research Institute, Mark Hopkins Hotel, San Francisco.
April 26–28	**ARS Propellants, Combustion, and Liquid Rockets Conference, Palm Beach Biltmore, Palm Beach, Fla.**
May 9–11	Western Joint Computer Conference, Ambassador Hotel, Los Angeles, Calif.
May 22–24	**ARS National Telemetering Conference, Chicago, Illinois.**
May 22–24	National Symposium on Global Communications, co-sponsored by AIEE and IRE, Hotel Sherman, Chicago, Ill.
June 14–17	**ARS Semi-Annual Meeting, Ambassador Hotel, Los Angeles.**
Aug. 21–23	**ARS International Hypersonics Conference, MIT, Cambridge, Mass.**
Aug. 23–25	**ARS Biennial Gas Dynamics Symposium, Northwestern Univ., Evanston, Ill.**
Aug. 28–Sept. 1	International Heat Transfer Conference, Univ. of Colorado, Boulder, Colo.
Oct. 9–13	**ARS SPACE FLIGHT REPORT TO THE NATION, New York Coliseum, New York, N.Y.**

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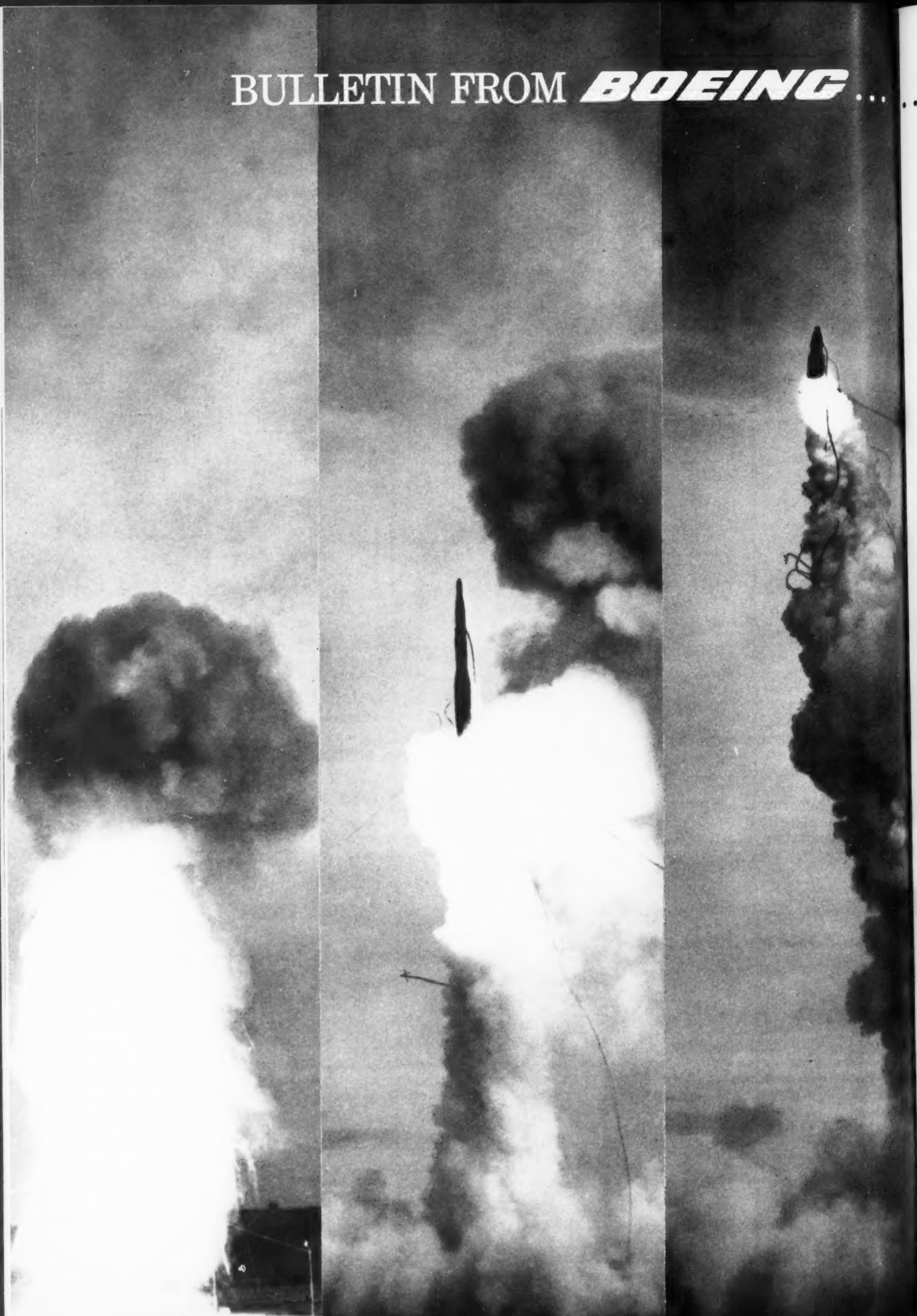

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...WHERE CAPABILITY HAS MANY FACES

Minuteman, the nation's first solid-fuel ICBM, blasts from underground silo, left, in tethered firing test. Successful Minuteman firings cut test program, saving millions of defense dollars. Boeing is weapon-system integrator of the 6000-mile-range Minuteman missile, now under development.

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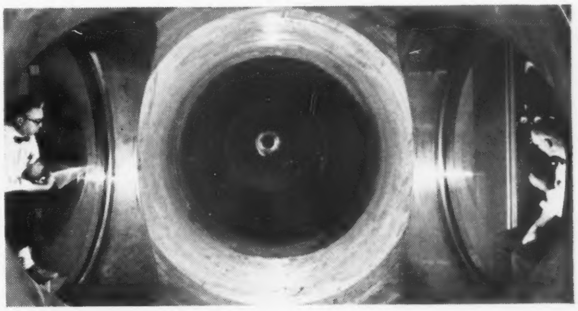

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JET AIRCRAFT, MISSILES, HELICOPTERS, TURBINES, WEAPON-SYSTEM MANAGEMENT, SPACE-FLIGHT VEHICLES AND SYSTEMS.

in a program under his direction to identify the natural history of arterial deposits. He showed a striking movie on this subject, and gave some of his data on the effect of elevated blood fats on physiological response. This space can not begin to do justice to the various experiments in progress that Dr. Talbot described.

In addition to the luncheons and dinner, field trips were available to WADD research and radiation laboratories. These were well attended considering the size of the meeting.

The Conference on Anatomy of Manned Space Operations proved disappointing in attendance and technical content. On the other hand, it provided another valuable measure of the need for a concerted effort in the human-factors field—to bring technically competent men of diverse training together in order that they may synthesize their knowledge and present it in a form understandable to the leading astronautical engineers; to give the continuing splinter meetings on human factors more coordination and force; and to plan for a future meeting of major proportions that will put long-term developments into perspective for engineers responsible for life-support systems.

—John Newbauer

Panel Discussion on Life Sciences Grants And Contracts Now Available as ARS Preprint

The joint presentations of the panel on government grants and contracts—representing NASA, the AEC, the Office of Naval Research, the Air Force, DOD, the Army, and the National Institutes of Health—given at the ARS Conference on the Anatomy of Manned Space Operations recently, are available from ARS Headquarters (Dayton Conference Proceedings Secretary), 500 5th Ave., New York 36, N.Y., as a single report costing $2.00 per copy. The presentations describe how to approach each agency with unsolicited proposals. Most of these agencies contemplate large and expanding budgets for research in the life sciences.

Seven More Companies Become Corporate Members

Seven companies—Bendix Corp., Bermite Powder Co., CTL Div. of Studebaker-Packard Corp., Itek Corp., Rosan, Inc., Universal Match Corp., and Weatherhead Co.—have joined the list of ARS Corporate Members participating in Society activities. The companies, their areas of activity, and those named to represent them in ARS affairs are:

Bendix Corporation, Detroit, Mich., prime contractor in guided missile field, responsible for Eagle missile system and the Talos missile. Also develops and builds controls and hardware for solid and liquid rockets. Representing the company are R. D. O'Neal, vice-president, engineering; D. M. Heller and A. C. Omberg, both assistant group executives, Bendix Products Div.; R. J. Sandstrom and C. M. Shaar, general manager and associate technical director, respectively, Bendix Systems Div.

Bermite Powder Co., Saugus, Calif., engaged in research, development, manufacture, and technical advance application of physical and engineering sciences. Representing the company are Patrick Lizza, president and general manager; Hugo Lizza, vice-president and assistant general manager; J. Arnold, vice-president and treasurer; Louis LoFiego, director of research and development; and Joseph B. Tortorici, division manager, ORDCO.

CTL Div. of Studebaker-Packard Corp., Cincinnati, Ohio, producer of reinforced plastics, particularly in reentry vehicle protection and rocket motor hardware. Named to represent the company are R. W. Pollock, director of technical services; Charles Chamberlin, Joseph Wiechowski, and John S. Malott, technical services representatives; and Raymond E. Silbernagel, director of research.

Itek Corporation, Waltham, Mass., manufactures space vehicle instrumentation and aerial reconnaissance and photographic tracking systems. Representing Itek in Society activities are John T. Watson, Claus Aschenhrenner, John H. Frailey, Robert E. Shannon, and Thomas Hoban.

American Rocket Society

500 Fifth Avenue, New York 36, N. Y.

Founded 1930

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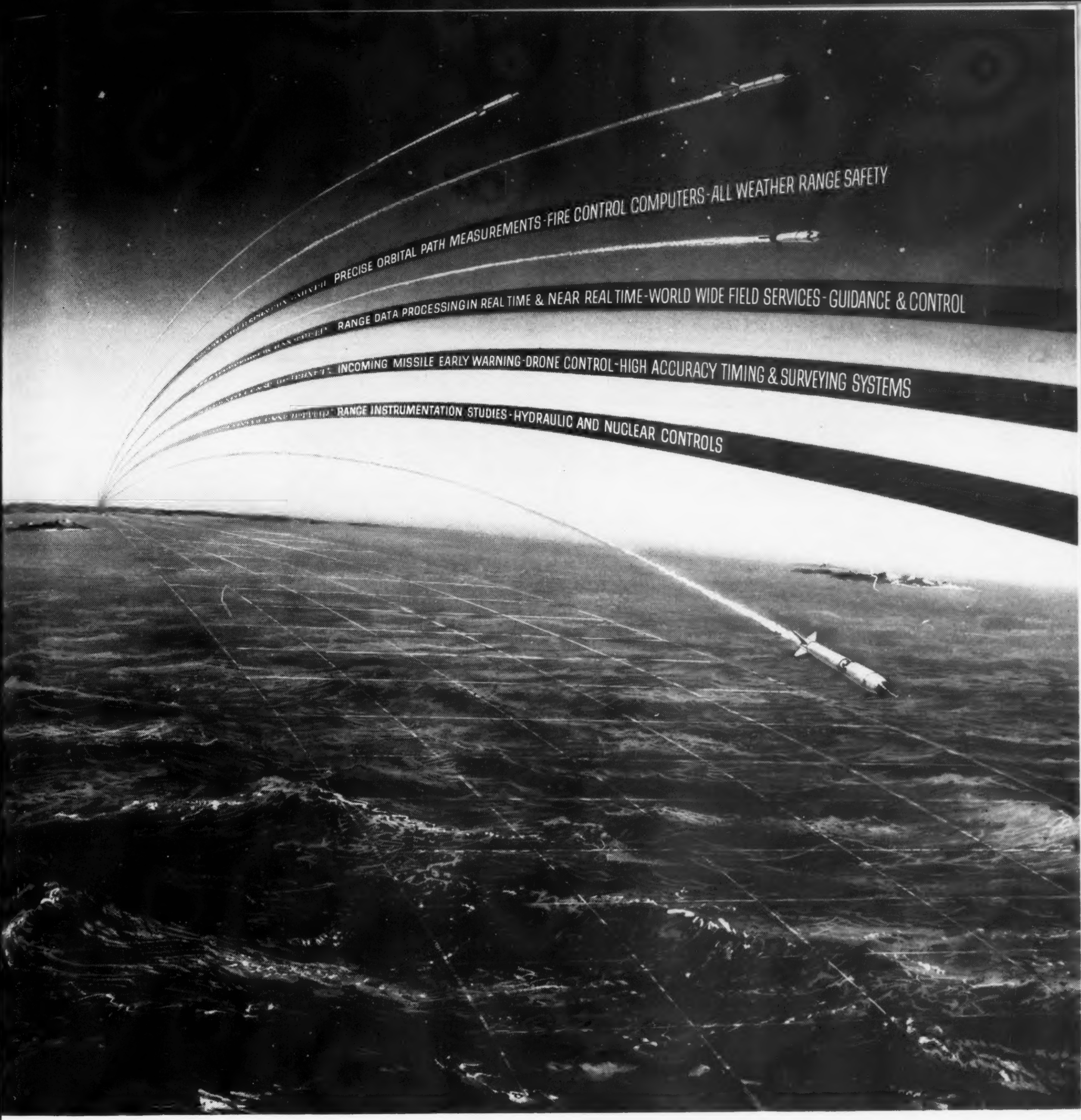


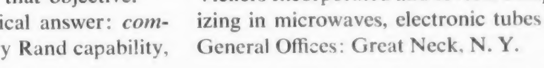
THE MISSILE RANGE: Measure of Capability

The missile range today is a vast proving ground for advanced technologies. It symbolizes the "state of the art" in computation, physics, chemistry, metallurgy, propulsion, hydraulics, electronics, inertial guidance, communications and every other scientific field.

The most critical need of the missile range is to *know system performance exactly*. This calls for integrated standards of measurement and data handling, and therefore for entire systems and entire installations engineered to that objective.

To this problem Sperry Rand has a logical answer: *compatible instrumentation*. The scope of Sperry Rand capability, illustrated above, embraces the whole panorama of the space age. Compatible Instrumentation is the principle of precision in missile range measurement, and a plan of action for applying this principle to projects now developing.

For the necessary team approach to missile range technology Sperry capabilities are joined with those of all other corporate divisions which have contributions to make—among them Ford Instrument Company, Remington Rand Univac, Vickers Incorporated and several component divisions specializing in microwaves, electronic tubes and solid state devices. General Offices: Great Neck, N. Y.



SPERRY

Rosan, Inc., Newport Beach, Calif., producer of precision (mechanical, hydraulic, and electronic) fasteners. Representing the company are Jose Rosan, president; Jose Rosan Jr., vice-president and general manager; Howard Suter, chief engineer; H. R. Alexander, vice-president, technical sales; and Albert J. LaTorre, director of research and development.

Universal Match Corp., Armament Div., Ferguson, Mo., work on guided missile launching equipment and explosively actuated components. Representing the company are Allan W. Lindberg, head, Department of Applied Research; John R. Quick Sr., development engineer; Donald G. Farley, staff engineer; Carl G. Gottlieb, manager, Armament Div.; and Max E. Norman, manager, Avionics and Electronics Dept.

Weatherhead Co., Cleveland, Ohio, manufacturer of fittings, valves, hose assemblies and components of hydraulic systems for aviation and missile industries. Representing the company are Albert J. Weatherhead Jr., president; Albert J. Weatherhead III, vice-president and general manager; Bruce H. Pauly, director of research and development; Ralph T. Marette, senior project manager, R&D; and Austin E. Pettyjohn, project manager, R&D.

Bound Volumes of ARS Publications Available

Bound volumes of the 1958 and 1959 issues of *Astronautics* and *ARS Journal* are now available in limited quantities from ARS Headquarters. The volumes, covering the complete year, are bound in buckram and stamped in gold lettering, and include a separate index.

Since the quantities are limited, the volumes are being offered on a first-come, first-served basis. Prices are $20 each for the 1958 and 1959 volumes of *Astronautics*, and $25 each for the 1958 and 1959 volumes of *ARS Journal*. Orders, accompanied by check or money order, should be addressed to Dept. B, American Rocket Society, 500 Fifth Ave., New York 36, N.Y.

SECTION NEWS

Columbus: The October meeting of the Section, attended by 92 members and guests, was held in the new Evans Laboratory of Chemistry on the

For Space Power Systems

Walter K. Deacon, left, chief engineer of Vickers Inc., presents luncheon speaker Chauncey Starr, president of Atomics International, to the recent highly successful ARS Power Systems Conference. Deacon chaired this first major conference in the space power systems field.

Ohio State Univ. campus. Prior to the business meeting, a film on the X-15 project was shown.

Kenneth Greenlee, Section vice-president, introduced the guest speaker for the evening, **H. Warren Plohr** of the Lewis Research Laboratory, who presented a very good review of Project Mercury. He described the escape rockets that are used immediately after launch in case of an emergency, the retrorockets that are to be used for recovery from orbit, and the attitude rockets or jets that are used for orientation of the capsule during the orbit. He also spoke of the recovery procedure that will be used in case the capsule is unable to complete its mission from launch to the planned recovery point. Plohr highlighted his presentation with a model of the Atlas and capsule, slides, and a short movie of the launch of a dummy capsule. The sound track of the movie was a recording made inside of the capsule during flight.

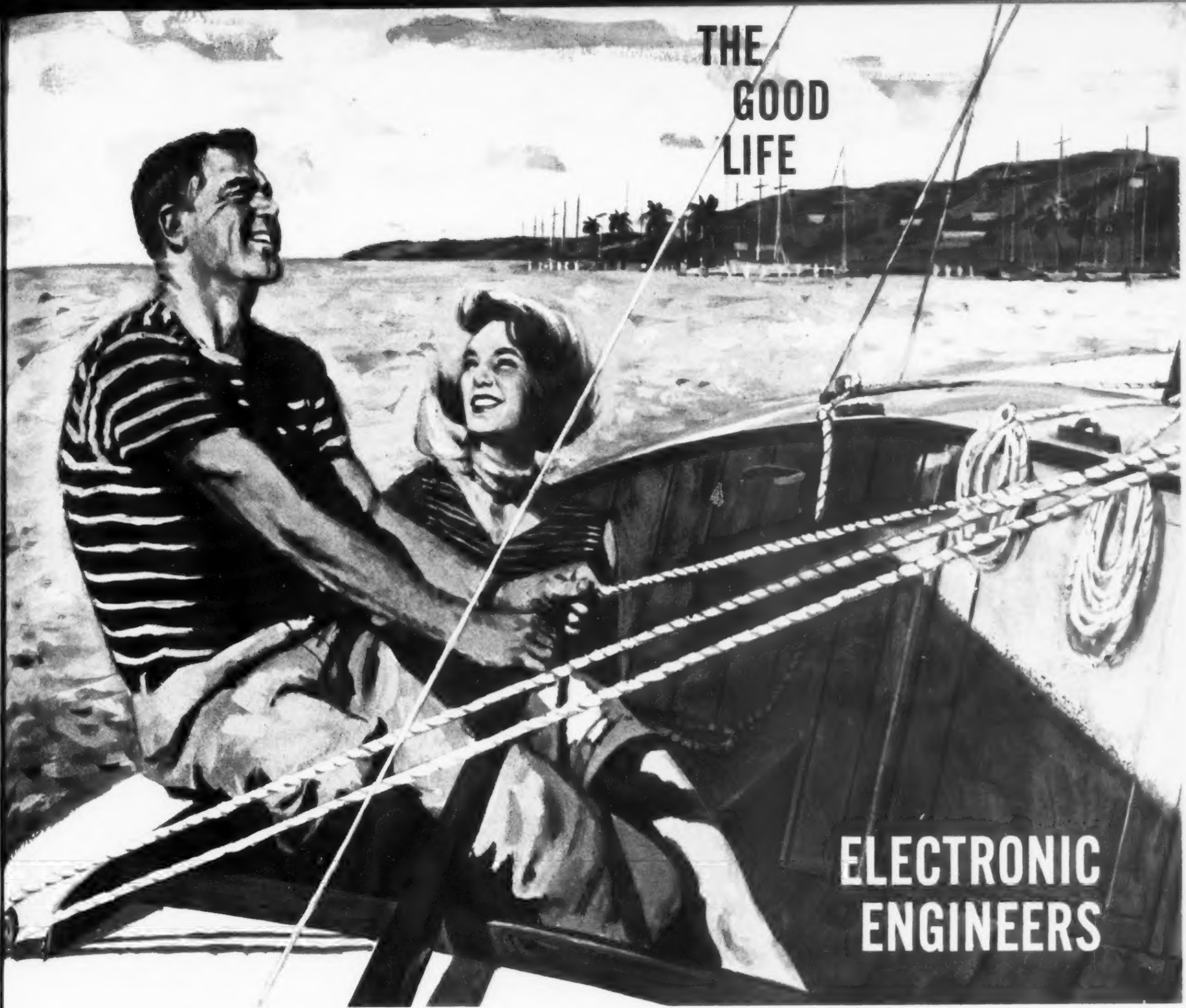
—**James A. Loughrey**

Detroit: In October, **William H. Pickering**, director of JPL, was the featured speaker at a dinner meeting attended by about 90 persons. His talk, "Where Do We Stand in Space?", was given to approximately 175 members and guests, and was preceded by a movie covering Project Echo, showing that program from its birth to the successful launch and radio relay activities. Following the movie, Dr. Pickering reviewed the past five years of space effort, including the Russian efforts beginning with Sputnik I just three years ago. Following this, a stimulating question-and-answer period was held.

Included in the audience were many ladies, members of the local Air Force reserve squadron, and some of the faculty and members of Wayne State

GE Solar Test Facility Planned

This architect's drawing illustrates the solar test facility which GE's Missile and Space Vehicle Dept. plans to erect near Phoenix, Ariz. The facility will have a large movable section that can be rolled away to expose equipment to the sun, and will be sizable enough to test the largest solar-powered static generating systems presently being built for space power applications. At first, solar collectors as large as 21 ft in diam will be housable in the movable section. There is an average of 210 clear days a year in Phoenix.



Engineers (and everyone else, for that matter) enjoy the *good life* in climate-perfect San Diego, California. Whatever your choice of family recreation or entertainment, San Diego is richly endowed with year-'round attractions. Beaches, mountains, deserts, lakes . . . all are close by. The many public golf courses are uncrowded and open 12 months a year. Nearby Tijuana in Old Mexico, offers thoroughbred racing, bull fights, dog races, and warm, Latin-American hospitality.

With all its casual informality, San Diego is a cosmopolitan city of over one-half million. Many fine restaurants offer a variety of cuisine and entertainment; cultural attractions include opera, theater, museums, musical road shows. The world's largest zoo is located within the 1400 rambling acres of Balboa Park in downtown San Diego.

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You'll find more information about Astronautics, its facilities, and its role in space exploration on the next page. Why not get the full story by returning the attached inquiry card today? No obligation, of course, and your reply will be held in strict confidence. For a prompt acknowledgement write to Mr. R. B. Merwin, Industrial Relations Administrator-Engineering, Dept. 130-90, Convair Astronautics, 5577 Kearny Villa Road, San Diego, California.

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Engineering Psychologists and Industrial Engineers with a hardware background to develop manning documents, perform task analysis, and develop tables of organization and equipment for the Atlas Weapons system.

Engineering Writers with 2 years college and 3 years experience in the preparation of TCTO's; Operations, Maintenance, and Overhaul manuals.

Guidance System Analysts to define the optimum characteristics, philosophy, and mode of operation of sophisticated guidance systems of extreme accuracy. A Ph.D. degree plus experience in guidance systems and missile simulation is desired, but more extensive experience in related fields will be favorably considered.

Pre-Design Engineers with experience in proposal preparation and system design of guidance and tracking systems.

If you desire to become part of this great team, we urge your prompt inquiry on the attached Engineering Placement Inquiry.

Technical openings also exist in other specialties. Write Mr. R. B. Merwin, Industrial Relations Administrator-Engineering, Dept. 130-90, Convair Astronautics, 5577 Kearny Villa Road, San Diego, California.

CONVAIR / ASTRONAUTICS

CONVAIR DIVISION OF GENERAL DYNAMICS

Univ. Student Chapter sponsored by the parent Detroit Section.

—J. M. Dutton

Florida: At the October meeting, held in the Officers' Club at Patrick AFB, a distinguished authority on space propulsion, **Mark Ghai,** manager of electrical space propulsion for GE's Flight Propulsion Laboratory Dept., addressed section members and guests.

Introduced by Col. Prentice Peabody, Section president, Dr. Ghai discussed various methods that can be used for space travel, such as gas bottles and chemical, nuclear, and electrical rockets. The electrical rockets, such as the electro-thermo (arc) jet, electrostatic, and the electromagnetic (MDH or plasma) devices, were discussed in some detail.

—Bob Eley

New York: The Section held a field trip jointly with the local group of IAS in October to the Hayden Planetarium in New York City. **Kenneth L. Franklin,** a Hayden associate astronomer, discussed the geocentric features of the night sky, and demonstrated them with the Planetarium's new Zeiss planetarium projector. Dr. Franklin also showed some extraordinary moving pictures of sun spots and prominences. The meeting, sponsored by the Kollsman Instrument Corp. of Elmhurst, N.Y., was well attended.

Seifert on ICBM Program

ARS President Howard Seifert looks over the meeting schedule for the St. Joseph Valley Section with Section vice-president Marv Ehrenberg, left, and Section President Bruce Bishop, center, before discussing headaches involved in the nation's ballistic-missile program for the St. Joseph membership.

Solid Rocket Conference Chairman Named

Joseph H. McKenna, marketing manager at Thiokol's Utah Div. and president of the ARS Utah Section, has been named general chairman of the ARS Solid Propellant Rocket Conference, to be held February 1–3 at the Hotel Utah in Salt Lake City.

Northern California: An outstanding meeting of the Section was held at Dinah's Shack in Palo Alto in October. After an enjoyable social hour and dinner, the guest speaker for the evening, **Donald C. Bowersock Jr.** of Arthur D. Little Inc., presented an excellent talk titled, "One Hundred Years with Cryogenics." He pointed out, among other things, that many problems associated with the use of liquid fluorine for high-energy propellant systems are gradually being resolved. Two films on liquid-hydrogen safety problems were presented. ADL studies have shown that hydrogen-air mixtures ignited by hot sources will not detonate if not confined. Thus spillage of liquid hydrogen in air is not exceedingly dangerous. Propagation of the flame through the atmospheric cloud of gaseous hydrogen apparently does not exceed about 100 ft. However, mixtures of liquid hydrogen and liquid oxygen do explode when ignited. Obviously, special precautions are required when working with the combination of liquids.

Pacific Missile Range: "A Survey of Present Space Programs" was the title of a lecture by **Donald P. LeGalley** given to 80 Section members, October 18, at a dinner meeting at the Point Mugu Officers' Club.

With the latest data on film and slides showing American and Soviet space-vehicle data, he stressed the scientific contributions of our satellites, and the fact that this has been achieved by our efforts toward miniaturization of highly sophisticated instrumentation. He felt that this outweighed the Soviet's emphasis on sending heavy packages into space. This country could have done the same, he felt, but for the refusal of the Dept. of Defense to release military boosters at a time when the Russians were engaged in a total effort.

Dr. LeGalley, who is with the Office of Scientific and Engineering Relations of Space Technology Laboratories, has had a long and distinguished career in the field of rockets and missiles. This has included 10 years with the Navy, half in the Bureau of Ordnance and half in the Office of the Chief of Naval Operations. In addition to conducting some of the initial studies of inertial-guidance systems, he was active in the first launching of a German V-2 missile from the deck of the USS Midway in 1947. In 1948 he helped to initiate the first conceptual studies of the Navy's missile project now known as Polaris.

The meeting was attended by Capt. W. E. Sweeney, deputy commander of the Pacific Missile Range; Capt. Peter F. Boyle, commanding officer of the Naval Air Station, Point Mugu; Capt. Carl E. Pruett, MC, Bio-Science Officer of the PMR; and Capt. E. W. Harrison, planning officer of the Missile and Astronautics Directorate.

—Arthur Menken

Philadelphia: The Section kicked-off its 1960–61 season with a presentation on the Polaris program by **Comdr. T. R. Rhees,** USN, before a capacity crowd of over 200 at the Bristol Motel, Bristol, Pa. A briefing officer for Admiral Raborn, Comdr. Rhees talked and showed slides and film on recent program milestones.

Kaiser Fleetwings served as host and conducted a tour of its Polaris production facilities for the group. **Jack Walton** of GE's Defense Systems Department, introduced the speaker.

—Arnold Koch

Princeton: Section President Sidney Sternberg welcomed members and guests to the October meeting and described plans for future meetings and invited suggestions of the members.

The guest speaker for the evening, **William O'Sullivan** of NASA Langley Research Center described the many interesting problems associated with the development of the sphere used in Project Echo as a passive reflector of radio signals. He described not only the final successful version but also detailed the failures and problems encountered over the period of development. The thermal balance, the structural requirements, the folding techniques, and the means for expanding the sphere in outer space were dealt with at some length.

—H. M. Gurin

Student Chapter Chartered at Notre Dame University

D. Cormier, president of the new Notre Dame Chapter of ARS, receives the charter from B. A. Bishop, left center, president of the St. Joseph Valley Chapter, as V. P. Goddard, faculty adviser, far left, and M. Ehrenberg, vice-president of St. Joseph Valley, far right, look on in informal ceremonies after the installation meeting.

St. Joseph Valley: Two hundred and fifty engineers, students, and interested parties turned out in September to hear **ARS President Howard S. Seifert** speak on "The Headaches of the ICBM Program," discussing, in retrospect, the philosophy of a "crash" program such as the U.S. ICBM effort, as well as the broad range of technical and organizational problems involved, from the deeply fundamental to the most immediately practical.

A dinner was served before the evening's program. Section President Bruce Bishop presided over the program.

—L. J. Boler

STUDENT CHAPTERS

Univ. of Oklahoma: The Chapter held its first meeting of the 1960–61 school year conjointly with Sigma Gamma Tau, honorary aeronautical engineering society, in October. John Totten, Chapter president, presided and gave a brief explanation of the nature of ARS and its plans for next year. Then the movie "Vertical Frontiers" was shown.

—Mike Ruby

CORPORATE MEMBERS

Aerojet-General has purchased a controlling interest in Space Electronics Corp. from Pacific Automation Products, Inc., to supplement its own recently expanded Spacecraft Div. . . **Chance Vought Aircraft, Inc.,** is in the process of changing its corporate name to Chance Vought Corporation, to reflect the company's diversity more accurately . . . **Ford Motor's Aeronutronic Div.** is adding another major building to its Engineering and Research Center . . . **Grand Central Rocket's** board of directors has approved continuation of the company's master construction plan for complete, advanced-design facilities, adopted in late 1959.

Through the support of **The Martin Co.** and the National Bureau of Standards, a new Institute of Measurement Science, this country's first, will be established at George Washington Univ.'s School of Engineering. First classes will be held beginning next February. Martin also has made arrangements to use part of Pennsylvania State Univ.'s nuclear research facilities at Quehanna, Pa., for work in the development of isotopic power . . . **Marquardt Corp.'s** Cooper Development Div. will move from Monrovia to Van Nuys, Calif., location of Marquardt's Power Systems Group . . . **North American Aviation's** Autonetics Div. has announced plans for building of an Electronics Research Center later this year.

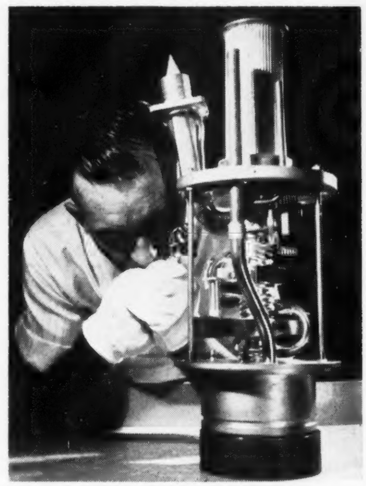
Philco Corp. has set up a fifth division within its Government and Industrial Group and will house it at Ft. Washington Industrial Park, Pa. . . . **Radio Corporation of America** has opened an Electronic Data Processing Center in Chicago . . . **Republic Aviation** plans to build a hypersonic wind tunnel for study of re-entry problems of vehicles traveling up to Mach 14 . . . **Ryan Aeronautical** has formed two subsidiaries: Ryan Transdata, Inc., to specialize in design and development of data handling equipment, and Ryan Communications, Inc., to specialize in solving communications problems . . . **Texas Instruments** has established the Walter F. Joyce Foundation, a non-profit activity for the study and investigation of geophysical and geochemical phenomena. Initial grant of about $60,000 will be made to MIT for tho study of radon gas.

TRW Computers Co. has been announced as the new name for Thompson-Ramo-Wooldridge Products Co. **Thompson Ramo Wooldridge, Inc.'s,** subsidiary, Pacific Semiconductors, Inc., has transferred its corporate headquarters from Culver City, Calif., to a new facility at Lawndale . . . **United Technology Corp. of United Aircraft** has moved into new headquarters at its multimillion dollar Research and Engineering Center at Sunnyvale, Calif. . . . The Nems-Clarke Co., a division of **Vitro Corporation of America,** has changed its name to Vitro Electronics, a division of VCA. The Nems-Clarke designation will be retained as a trade name.

1960 National Telemetering Conference Proceedings Ready

The Proceedings of the National Telemetering Conference, held May 23–25 at the Miramar Hotel in Santa Monica, Calif., are available now from ARS Headquarters, 500 5th Ave., New York 36, N. Y., at $4.50 per copy to members and $6.00 per copy to nonmembers.

Greater Radar Reach



This C-band klystron tube, developed by Sperry Gyroscope, supplies 3-million watts of precise radar power for detecting, guiding, or tracking supersonic vehicles at longer ranges than formerly possible. It is the first klystron to generate such intense radar energy at frequencies above 4-billion cps.

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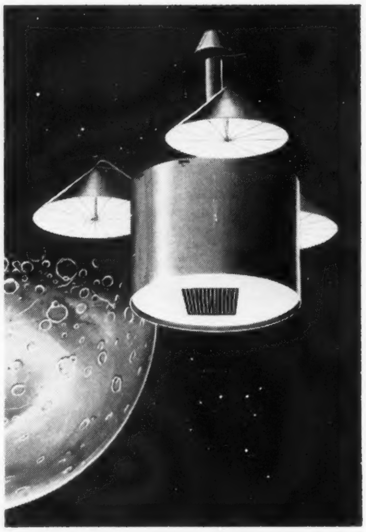
A "Heliodyne" Proposed

Pictured as it orbits close to the moon is the Northrop-proposed Heliodyne, a space vehicle designed to explore the solar system. This vehicle would employ only two moving parts—a set of louvers, at the end of a tank holding about a ton of liquid hydrogen, that would regulate heat transfer and keep tank pressure constant; and a throttle to regulate flow of hydrogen into fine tubes at the center of three conical mirrors directing the sun's rays against them. Thus focused, the rays would heat the hydrogen and expel it, producing propulsive force. Direction of the mirrors against the hydrogen-containing tubes, and thus determination of the periods and power of propulsion, could be controlled automatically from within the vehicle or from the earth by radio-command link. The probe-like structure behind the mirrors carries the vehicle's instruments.



An impression of Northrop's Heliodyne proposal.

Megawatt Electrical Power

(CONTINUED FROM PAGE 27)

power system, one must first examine what reasonable possibilities exist, and then compare them on the basis of reliability, weight, life, etc. For a unit operating at a 1-megawatt level, the nuclear-powered, Rankine-cycle heat engine and the nuclear-plasma-diode powerplant are the most attractive systems.

Consider first a nuclear-plasma-diode powerplant. A nuclear plasma diode to be competitive with a nuclear turboelectric system in weight at this large power level requires high power density and high-temperature operation (e.g., 4000 F). This means removing several hundred thousand Btu/hr-sq ft at high temperatures. Efficient heat removal at such high rates and temperatures requires the use of a forced-convection, liquid-metal heat removal system. This imposes material and insulation problems, which, if not solved, limit the nuclear plasma diode to a very low voltage output. In addition, the necessity for operation of nuclear fuel elements at 4000 F for long periods of time makes uncertain the containment of the uranium fuel and fission products. Even if these problems are completely solved, the nuclear-plasma-diode system would have no significant reliability or weight advantage over the nuclear turboelectric system described in this paper. (For instance, see "Space Nuclear Power Conversion Systems," by C. E. Johnson, M. G. Coombs, and R. L. Hirsch, Atomics International, 1960 Proceedings of the National Aeronautical Electronics Conference, Dayton, Ohio.) Hence, for large electric power systems in space, the Rankine-cycle heat engine powered by a nuclear reactor appears to be the most feasible type of power-conversion system for development during at least the next decade.

Reliability, there is no argument, becomes of prime importance in the design of very large electric power systems for space vehicles. Rotating-machinery reliability has been proved many times. A classic example is the directly analogous Rankine-cycle central station powerplant which runs for considerably over a year without shutdown. Even then, shutdown usually occurs because it is necessary to clean out the boiler due to fouling by combustion gases. High reliability can be achieved with moving or rotating machinery.

Before proceeding to the conceptual design of an advanced 1-megawatt system, a review of current turboelectric space-power programs is appropriate. These include among others the Atomic Energy Commission-sponsored Snap-1 and Snap-2 programs initiated in 1956 and the Wright Air Development Div.-sponsored Solar Power Demonstrator Unit (Spud) program initiated in 1959. The 0.5-kw Snap-1 turboelectric system, designed for operation with a radioisotope heat source, the 3-kw Snap-2 system designed for use with a nuclear heat source, and the 1.0-kw Spud Unit all employ a mercury Rankine cycle.

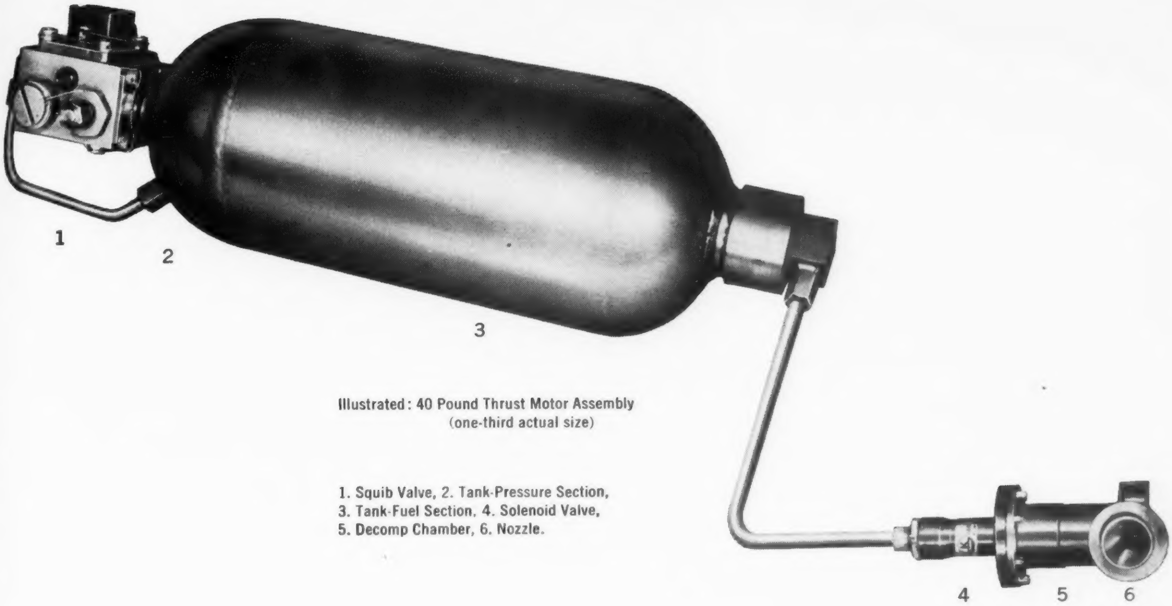
These programs have reached an advanced state of development. Machinery has been successfully operated for many thousands of hours of continuous operation. One unit has accumulated over 3000 hr of continuous operation and is still running successfully at the time of this writing. Specific accomplishments demonstrated in the course of these programs include: (a) Development of high-speed, high-performance metal-vapor turbines; (b) development of hermetically sealed alternators capable of continuous operation at 700 F in a liquid-metal-vapor environment; (c) development of high-speed liquid-metal-lubricated bearings; (d) materials and fabrication methods assuring long operation; and (e) stable boiling and condensing in a gravitationless environment. These developments provide the art for the next generation of space powerplants.

From experience obtained in these programs, it appears fairly certain that a liquid-metal-vapor Rankine cycle offers a practical means of generating electrical power for space applications. For powerplants generating less than 100 kw of electricity (such as those in the Snap program), mercury vapor is an attractive choice of working fluid. However, for a 1-megawatt mercury-vapor plant, the radiator area becomes excessive, and the use of a working fluid which condenses at higher temperatures is indicated. Higher condensing temperatures imply higher maximum cycle temperature. The upper cycle temperature is limited by reactor materials and technology.

Performance of Refractories

Refractory metal alloys are being developed with sufficient 10,000-hr creep strength to permit increases of maximum cycle temperature to 1800 F. This appears to be a reasonable upper-cycle temperature for systems beginning development in the near future. At this temperature, the vapor pressure of mercury is excessive, and other working fluids are required. The alkali metals, because of their heat-removal properties and thermodynamic properties, and stability in the nuclear and thermal environment, are attractive. In addition, their compatibility with refractory metals at these temperatures appears good. (See, for example, "Properties of Inorganic Working Fluids and Coolants for Space Applications," by W. D. Weatherford Jr., J. C. Tyler, and P. M. Ku, Southwest Research Institute, WADC Technical Report 59-598.)

For operation in the temperature range considered, vapor-pressure considerations dictate the choice of either



Illustrated: 40 Pound Thrust Motor Assembly
(one-third actual size)

1. Squib Valve, 2. Tank-Pressure Section,
3. Tank-Fuel Section, 4. Solenoid Valve,
5. Decomp Chamber, 6. Nozzle.

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potassium or rubidium as the working fluid. Vapor-pressure and pump-cavitation considerations require that a sodium system operate at higher condenser temperatures than either a rubidium or potassium system. Hence, in order for a sodium system to have cycle efficiencies competitive with potassium or rubidium, much higher maximum cycle temperatures are required. At present, it appears that a sodium vapor cycle requires too great an advance in the state of the art.

Advantage of Potassium

Potassium has an advantage over rubidium from the standpoint of heat removal, cost, availability, and inventory. Pumping considerations favor potassium as less pump work is involved. Potassium and rubidium can operate at identical condenser temperatures from the pump-cavitation standpoint, as suction specific speed is equal for both fluids. Rubidium has the advantage of requiring smaller vapor-duct diameters at turbine-exhaust conditions, for a given pressure drop to pressure ratio. However, the condenser used in the system that will be described reduces this advantage to insignificance. All-in-all, based on a careful weighing of these factors, the more readily available potassium will give the lightest-weight system and is a more attractive working fluid.

In selecting an energy source, the following requirements must be met: (a) Minimum size and weight (Reactor size is very important, since shielding weight is very dependent on core volume); and (b) high-temperature, long-term operation.

The fast reactor, inherently compact, can satisfy these requirements if a proper diluent is chosen. This diluent should contain high uranium density. Fuel burnup must be consistent with long operation at these temperatures and power densities. Compact intermediate or epithermal reactors also offer possibilities.

Direct boiling and indirect liquid cooling are two means of heat removal from the nuclear reactor. Direct boiling with recirculation is attractive in that it eliminates the high-temperature heat exchanger-boiler and the coolant pump. In addition, it permits operation at lower reactor temperatures for given turbine-inlet conditions. Whether the direct-boiling-cooled reactor offers as compact a reactor design as a liquid-cooled reactor for this 1-megawatt system depends on the result of future boiling-burnout tests with potassium. The liquid-cooled reactor offers the advantages of more accumulated design experience and greater growth potential for higher powers. Everything considered, we would select a liquid-cooled reactor for the 1-megawatt system.

The sketch on page 27 illustrates a conceptual design of a 1-megawatt nuclear potassium vapor power system that summarizes our design choices.

An inherently compact lithium-cooled fast reactor is utilized as the energy source. A canned motor-pump circulates the lithium, transferring the reactor heat to the potassium boiler. Vapor at low quality from the boiler enters a two-stage stationary centrifugal separator, from whence the liquid is recirculated by a jet pump through the boiler. The separated saturated vapor passes to the turbine.

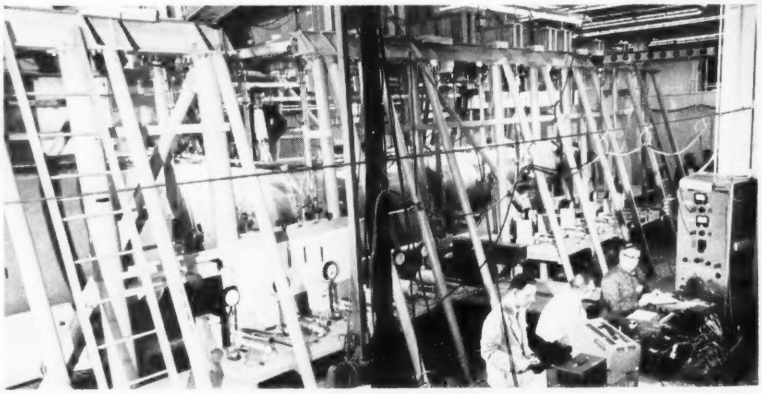
Four 250-kw hermetically sealed rotating units produce the 1 megawatt. These rotating units contain turbine, alternators, and a jet-boosted centrifugal condensate pump, as indicated in the schematic of the component arrangements on page 26. The maximum practical rotating speed based upon material and electrical limitations is 24,000 rpm. This speed provides nearly optimum specific weight for the electrical machinery, satisfies the aerodynamic needs of the turbine, and allows satisfactory pump specific speeds. By going to multiple units operating at higher speeds, the total weight of the turbine alternator portion of the system is reduced. The weight of a 1-megawatt alternator is 2200 lb as compared to a total of 1500 lb for four 250-kw alternators. One significant advantage of the multiple-unit system is that a failure in one unit still permits delivery of more than three-fourths of the power. This design philosophy is carried over in the entire system—a failure of any one component still permits delivery of a major portion of the design power.

The alternators in each rotating package are mounted between the journal bearings, with the turbine and the pumps cantilevered from opposite ends of the shaft. These alternators consist of one producing 250 kw of 1600-cps power, an auxiliary alternator producing $2^1/_2$ kw of 400-cps power, and a control alternator. The 400-cps alternator provides power to drive the motor of the radiator and coolant pumps. These alternators, in the relatively cool environment between the turbine exhaust and pump, are maintained at 800 F by means of the coolant. By maintaining reduced pressure in the air gap, liquid entering that space is flashed to vapor and does not lower alternator efficiency. The adjacent bearings are lubricated with liquid potassium at 1000 F.

Two Heat-Rejection Systems

Two basic heat-rejection system concepts are possible. In the first, condensation takes place directly in the radiator. In the second, condensation occurs inside a compact heat exchanger, and the rejected heat is transferred to the radiating surface by a circulating liquid coolant.

The direct condenser is attractive for smaller power conversion systems (below 10 kw), where vapor headers are negligible in size and vapor passages are not numerous. A 1-megawatt system requires 2850 sq ft of radiator surface. If condensation were to take place directly in the radiator, large vapor headers and a



Minuteman Ready for Free-Flight Testing

Dynamic testing of the Air Force's Minuteman ICBM at Boeing's Aero-Space Div. in Seattle imposes stresses that simulate actual conditions of launch through burnout of all three solid-propellant stages. This testing is all but complete in preparation for free flights this fall.

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RCA Image Enhancement Techniques

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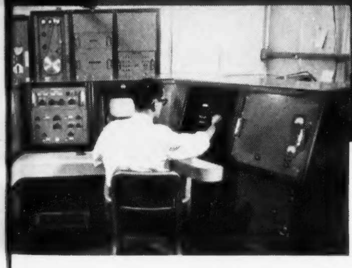

3. ELECTRONIC SLICING CONTRAST STRETCH in the intermediate level is an enhancement technique useful in object recognition.

◄ RCA Imagery Simulator and Enhancement Console

Image Enhancement, a new approach to photo interpretation developed by RCA Astro-Electronics Division, brings out hidden information from visual data. The RCA Image Enhancement Console quickly makes visible a wealth of information the unaided eye might not discern, by electronically emphasizing and/or de-emphasizing selected qualities inherent in any pictorial presentation.

Here are some of the ways the RCA Image Enhancement techniques aid image interpretation and information extraction:

- **SLICING**—Contrast "stretch" or video slicing provides increased contrast in a desired portion of the gray-scale transfer characteristics. It gives new vividness to selected details.
- **OUTLINING**—This produces an outline or contour of constant intensity, and of either polarity, along the loci of a selected video gray level. It emphasizes lines or areas of equal brightness quickly and is especially useful in delineating nebulous objects such as cloud formations.
- **DIFFERENTIATION**—This technique extracts interesting bas-relief effects and three dimensional light and shadow effects from pictorial information. It facilitates synoptic observations.

Image enhancement techniques are currently in experimental use. Applications in meteorology may include aid in interpretation of cloud cover photographs such as were taken by Tiros I. Enhancement techniques can aid in interpretation of all photographs taken during aerial and space reconnaissance missions. Unique image sensing methods such as radar, infrared and ultra-violet may benefit by enhancement. Medical and industrial x-ray analysts are extremely interested in the advantages which image enhancement may offer. Astronomers feel that these techniques will aid in their interpretation of photographs of the heavens. New applications are constantly being considered.

If you would like to fully explore the unique capabilities of the RCA Image Enhancement techniques, RCA's Space Center will welcome the opportunity to discuss them with you. Contact the Marketing Manager, RCA Astro-Electronics Division, Princeton, New Jersey.

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large number of passages over this area would be required. To minimize tube diameter and pressure drop, a relatively long vapor header would be required, feeding many short length tubes. Several of these large-aspect-ratio sections would then be paralleled to reduce vapor header size or pressure drop. Zero-g operation with stable flow is difficult to obtain in a direct condenser with such a large distribution network. Moreover, assurance of satisfactory condenser operation through zero-g testing of the direct condenser is impractical to achieve, since testing cannot be done on earth, and it is costly to test a 2850-sq-ft radiator in orbit. Condensation inside a compact heat exchanger circumvents these problems. Hence, this type is selected for the 1-megawatt design.

Heat-Exchanger Operation

Potassium vapor is introduced in the compact heat exchanger tangentially, and the passages containing the condensing fluid are directed so as to impart a centrifugal force field. Seven independent sodium circuits transport the heat rejected by the condenser to separate sections on the radiator. An additional independent coolant circuit is available to permit operation of the system at full power in the event of failure of any one of the seven sodium circuits. This coolant circuit can be put into operation by simply having electrical power supplied to the canned rotor-pump when overtemperature of the condenser is sensed during a failure. Based on 95-per cent probability of the heat-rejection system functioning at its design power at the end of a year, considering meteorite puncture as the failure mode, the use of a redundant radiator section yields a weight savings of over 600 lb. This is because the use of a redundant radiator section reduces the required meteorite-shield thickness necessary for a given probability of successful operation. The failure of two coolant circuits still permits six-sevenths of the design power to be rejected. The weight of the liquid radiator system can be additionally reduced because of the small header and tube diameters required by a liquid-cooled system. Savings in protection weight due to reduced radiator tube area are compounded, since lesser exposed area implies thinner protection as well as the smaller area to be covered. This is demonstrated by the low radiator specific weight of 0.8 lb/kw achieved in this design.

The indirect radiator provides greater freedom in the choice of aspect ratio for the radiator design and provides greater flexibility for integration of the powerplant with launch vehicles.

The radiator is a Y-shaped, three-span tube-fin configuration. Even though a small weight penalty is paid because of the reduced radiating effectiveness of the "Y" configuration, this arrangement gives a more compact design than a single span. Beryllium is used as both the fin material and the meteorite shield for the stainless-steel tubes. Sub-cooling heat rejection is provided by attaching radiating fins to the region between the condenser outlet and the pump inlet.

Sodium at 600 F is available for alternator and canned rotor-pump cooling. The heat rejection from this 600 F sodium takes place in an auxiliary radiator. For each radiator coolant circuit there is an independent circuit in the auxiliary radiator. The pump of this radiator is driven from the same shaft as the main radiator pump.

The control concept for the megawatt plant is strongly dependent upon the load schedule. For the ion-propulsion mission cited earlier, it is likely that the load will be held relatively constant for the complete mission, with any changes scheduled as slowly and continuously. For missions of this nature, the primary control can, and should, be on the reactor output power. A trim control using a parasitic element and dissipating a small part of the total load provides for minor high-speed load transients. A parasitic alternator in the rotating package dissipating its energy in a radiative load bank performs this function.

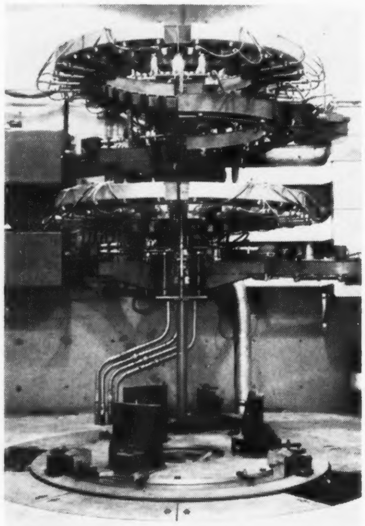
For large and rapid load changes, a different concept is required. In this case, the more conventional powerplant throttle and bypass arrangement combined with reactor control would be used, with the appropriate auxiliaries, such as de-superheater and boiler feed controls integrated into the over-all controls. Depending on the details of the load schedule, turboalternator modules might be taken off the line to permit system operation at reasonable part-load efficiency for long periods of time.

Electrical controls for paralleling of all the machines and for regulating the output voltage are provided. Paralleling causes a stiffening of the speed control of any one machine, and thereby enhances the capability for handling transients developed in the power cycle. Orbital startup of the machinery is provided; and, if required, shutdown and restart auxiliaries may also be included for individual units.

The specific weight of the unshielded 1-megawatt powerplant is 5.6 lb/kw. Shielding weight has not been included, since it depends on the specific mission. A shadow shield can protect the payload from direct beam radiation and from induced activation of the reactor coolant. For a manned vehicle, the shielding required for solar bursts and Van Allen shielding must be integrated with the reactor shield. By locating the radiator behind the reactor away from the payload and using separation between the payload and powerplant, scattered radiation can be minimized. In general, it is expected that shadow shielding will be more than 20 per cent of the powerplant weight for a manned vehicle.

The nuclear-potassium vapor power system presented here, offering a weight-to-power ratio of 5.6 lb/kw, is based on design features permitting development within the next seven years. Component design philosophy is such that in the event of a failure in a section of the powerplant, a major portion of the power will remain deliverable. The four rotating machinery packages and the independent condenser-radiators make this possible. Considering the expected availability of chemical-propellant boosters, such as Saturn, the development of a 1-megawatt power-conversion system would form an important element in the space power spectrum. ♦♦

Solid Rocket Inspector



This automatic machine, employing a cobalt 60 gamma ray source, inspects solid-propellant motors for cracks, bubbles, and fissures, as well as indicating whether the grain bonds properly to the motor case. The Rueker Co. built the machine as part of the Polaris motor development program, and has installed it for the Navy at Aerojet-General's Sacramento plant.

SPRINGBOARD FOR SPACE: LUNA

The moon is a ready-made space station for interplanetary exploration; space vehicles could be built, fueled, and launched there; lunar elements could be used to give man independence from earth. To help make this concept a reality, NAA's Missile Division has integrated the ideas of scientists in many fields and is studying how to reach the moon... how to live in its alien climate... how to process lunar matter. One example: a study of processes to obtain water from materials likely to be found on the moon.

THE MISSILE DIVISION OF NORTH AMERICAN AVIATION, INC.

Downey, California

Saturn

(CONTINUED FROM PAGE 33)

facilities, such as a mobile crane, will be necessary for removing salvaged components from the barge. As the recovery program becomes more extensive and, if the return of heavily damaged boosters requires heavier off-loading facilities, the RSA dock will have the capability for expansion to include construction of a 100-ton stiff-leg derrick with a reach of 85 ft to provide lifting facilities for a complete booster when it is returned in a damaged condition without its transporter.

Existing heavy-lift facilities at the New Orleans port are considered sufficient for transferring the recovered booster from the recovering LSD to the barge for return to RSA dock. Ramp facilities similar to those described for RSA dock will be used for unloading the booster-transporter at AMR, approximately 1 mi from Complex 34 on the Banana River.

With the sea-going barge, the loading at RSA dock will be accomplished by the roll-on, roll-off method. At New Orleans a river tug approximately 65 ft long will be exchanged for a sea-going tug approximately 100 ft long which will then tow the barge to Fort Pierce, Fla. Here the sea-going tug will be exchanged for a river tug which will complete the trip to Site C barge basin. The obvious advantage of this method of transportation is that no LSD loading and unloading of the barge is required, and the inherent possibility of damage to booster in such operations averted.

As to payloads, the proposed transporter for a lunar payload of 10-ft diam is essentially a modified version of a commercially available four-wheel transporter. The payload rests on a rear saddle, and is restrained and supported at the forward end by its lifting bolts. This is a proven system for missile transporters. It effectively prevents torsional strains from being introduced into the payload. Any commercial-type, small tug tractor with pintle hook may be used as prime mover for the payload transporter since road movement will normally be limited and will be accomplished on first-class roads. However, road speeds must not exceed 5 mph to prevent shock loading of the payload in excess of 4 g.

Payload dimensions will permit transport by C-133 aircraft, and this will be the normal method of transportation to the launch-site complex. Shipment of the payload will be made on the transporter to facilitate loading, unloading, and tie-down in the aircraft. Either rail or road facilities may be used for return shipment of the reusable materials and equipment from AMR to MSFC.

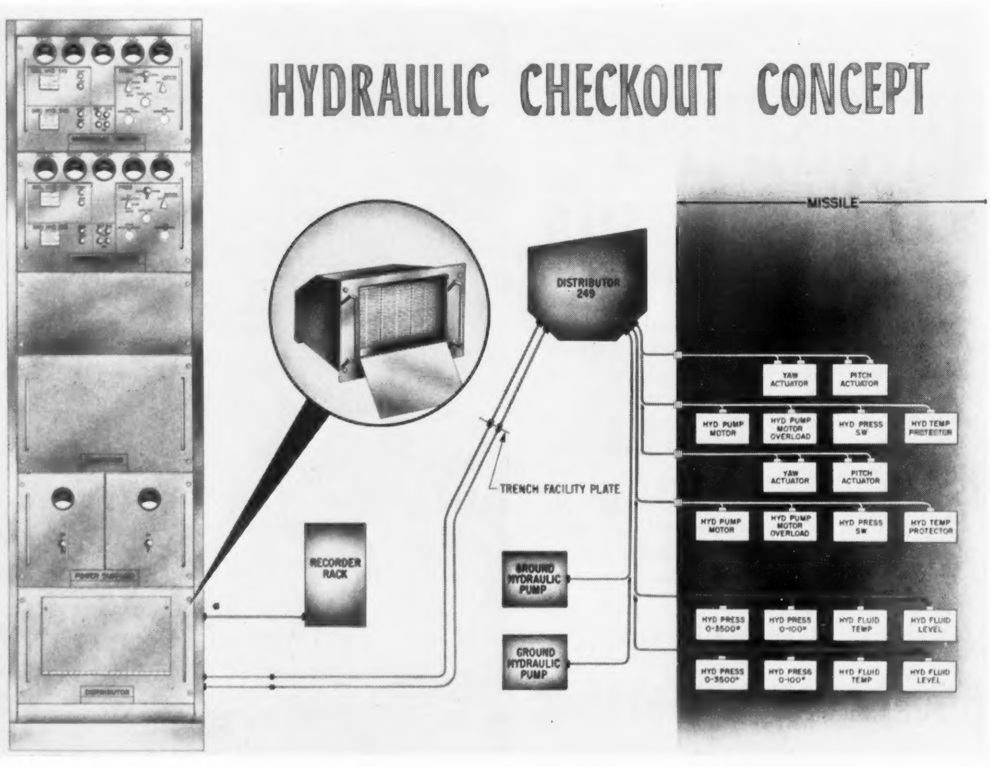
The outer skin of the payload will constitute the external container, in which the internal components will be living in a controlled environment. End covers and strippable coating will complete the sealing requirements. Desiccant breathers and appropriate venting will provide protection and prevent excessive differential pressures during air transport. Environmental protection will be provided by a waterproof tarpaulin or insulated blanket, as required by ambient conditions.

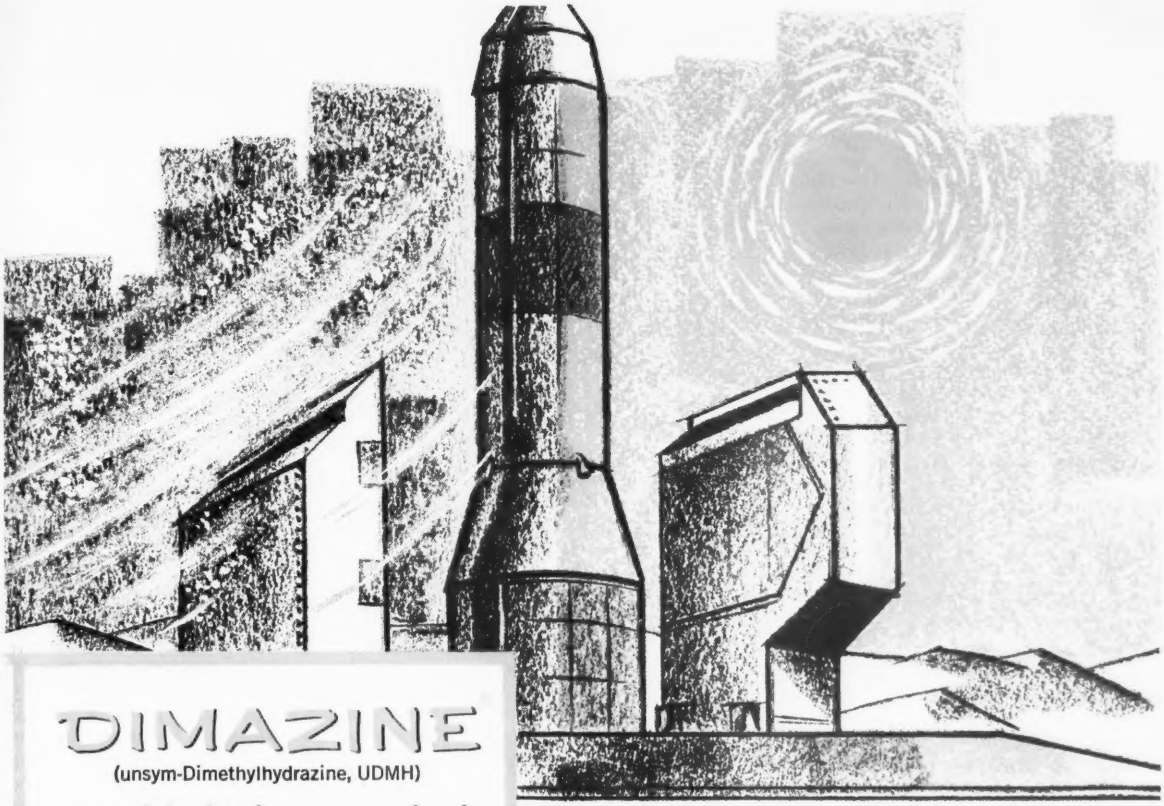
Launch Site

The Saturn launch complex, diagramed on page 31, contains all necessary facilities for handling, storing, servicing, checkout, erection, and launching of the Saturn vehicle, as well as the required administration, logistical, and laboratory facilities to support the various projects to be carried out during the Saturn program.

Upon arrival at the barge basin, the booster and transporter are off-loaded from the barge and towed to the launch pad for erection. The upper stage assemblies pass through an assembly building where final details and horizontal checkout are taken care of.

One launch-pad facility is sufficient to support Saturn firings at approximately two-month intervals. However, the propellant storage and trans-





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fer facilities are designed with the capability of supporting two launch pads at alternate intervals when required. This will be a requirement when lunar-payload missions are superimposed on other Saturn program schedules.

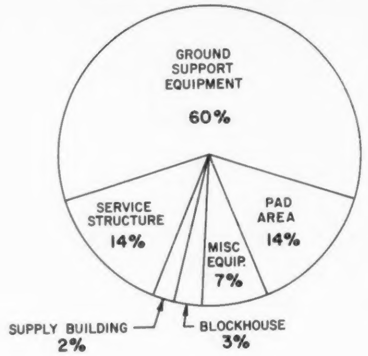
The Saturn booster is erected on the launcher by utilizing the track-mounted, gantry-type service structure. This structure has a bridge crane supporting two hooks, 40 and 60 tons capacity. The hooks are approximately 12 ft apart horizontally, and can be moved horizontally, longitudinally, and vertically. In preparation for erection, the service structure is positioned over the launcher, the booster transporter is towed into position parallel to the service structure base, and the booster is rotated 45 deg from transporting to erecting plane. The rear assembly ring is removed from the booster. The gantry crane is then moved into position and connected to the booster pickup points by erection slings and beams. The 60-ton hook is connected to the forward sling, and the 40-ton hook to the thrust-frame sling. The booster is lifted from the transporter, rotated into vertical position, moved into the gantry structure, and lowered onto four pre-leveled launcher support and hold-down points with the assistance of removable guides attached to launcher arms.

After erection, a pneumatic leak and function check is made on the booster to determine if any components or subsystems were damaged during transportation and handling. Gaseous nitrogen (GN_2), used in performance of the checks, is routed to the checkout panels on the launcher through a pneumatic distribution station in the base of the umbilical tower. The GN_2 pressure is regulated at these panels and, in conjunction with electrical control panels in the blockhouse, serve to distribute the GN_2 to various checkpoints throughout the system where function checks of the valves, leakage of joints and fittings, and flow-rate checks are performed. Pneumatic distribution lines also extend from the pneumatic distribution station to panels on the service structure for checkout of the top part of the booster.

Following pneumatic checkout, an engine service operation is performed using an engine servicing trailer. This operation includes flushing and purging of the critical portions of the engine, such as the fuel jacket, lox dome, gas generator, and fuel-igniter line to insure absolute cleanliness of these parts.

Lack of working space in the booster tail section makes it necessary to have a handling and hoisting system

PROPORTIONATE COSTS OF A SATURN LAUNCH FACILITY



capable of operation in a restricted area for removal and replacement of a defective engine after the booster is in the vertical position. Removal of an engine is accomplished by attaching a hoisting bar to the engine "rabbit ears" and the turbopump mounting frame. The engine is then lowered by a hoist and pulley until it is clear of adjacent engines and the booster structure. Then the engine is secured to a sled or skid which has been raised to position on a service platform. Half of the platform is then detached, lowered to the base of the launcher, and removed from the area on a monorail. The engine is then lowered on its skid along the face of the deflector by means of a cable and hoist arrangement to the base of the launcher, where it is removed from the area on the monorail. Reversal of this procedure is used to install a replacement engine.

Assembly of the upper stages is accomplished after booster checkout is completed. Details on these operations are not yet available.

Launcher Design

Let us turn now to the launcher and umbilical tower. The Saturn launcher is a reinforced-concrete and steel structure 42 ft square and 27 ft high. It has eight support arms. Four supports 90 deg apart are cantilevered at the outboard engines and are retracted horizontally after the valid commitment signal is given, to permit the engine shrouds to clear the vehicle during lift-off. The other four supports are dual-purpose support and holddown points located at 45 deg between the outboard engines. Holddown is accomplished by a toggle linkage which is activated when the retractable arms are fully retracted. In event of malfunction of one or more of the retractable supports, all four supports may be returned to position under the missile thrust frame prior to engine cut-off.

The umbilical tower is used to support and service the umbilical arms as well as to house and support the various electrical cables, pneumatic and lox replenishing lines, liquid nitrogen cooling tanks, mechanical refrigeration units, the ground hydraulic unit, and the pneumatic and electrical distribution station which are required to service the booster and upper stages prior to launching. The tower is 240 ft high and 24 ft square at the base. The bottom 27 ft of the tower is enclosed to provide for two air-conditioned equipment rooms. Above the 27-ft level, the four-tower columns slope inward to a 10-ft square at the top. Tower facilities include safety ladders and service platforms at 20-ft intervals, a 2000-lb capacity personnel and small-hardware elevator, and a 3000-lb capacity electric hoist at the top for handling lines, cables, and the umbilical arms.

Lox Facility

The lox facility for the Saturn complex consists of protective revetments, foundation, and partial weather protection for liquid-oxygen storage and transfer system. The system has the capability of servicing two pads from one facility at different intervals. The storage facility consists of an insulated sphere of 125,000-gal capacity and 41 ft in diam. This storage tank is insulated, but not vacuum jacketed, to sustain an evaporation loss of lox of 0.2%/24 hr. The working pressure of the sphere is 40 psig, which is maintained by a heat exchanger for self-pressurization. The booster transfer system consists basically of a 2500-gpm, 400-ft head pressure centrifugal cryogenic pump with associated valving necessary to transfer liquid through 750 ft of 8-in. uninsulated aluminum transfer line. Initial loading of oxidizer to the upper stages is facilitated by manifold lines connected to the umbilical tower and branching off at each stage servicing connection. The second-stage initial filling is accomplished by using a 1000-gpm, 600-ft head pressure pump and a 6-in. aluminum transfer line. The third-stage filling utilizes the same 1000-gpm pump, but is operated under throttled conditions.

Replenishing of the various stages is accomplished by using an additional 13,000-gal, 200-psi-working-pressure vacuum-jacketed tank located in the storage-facility confines. Replenishing of the booster and upper stages is accomplished by using a pneumatic-actuated modulating valve controlled by a lox tanking computer and level control associated with each of the stages to be replenished. The replenishing transfer lines for the booster,

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General Launch-Site Criteria for a Space Vehicle

1. Open water downrange to cover first- and second-stage fallout range
2. Eastward launchings
3. Growth potential
4. Adequate azimuth traverse for various missions
5. Available land downrange for tracking facilities
6. Moderate climatic conditions
7. Modest sea-traffic downrange
8. Soil characteristics, altitude, water supply, labor forces, local construction materials, personnel recruitment

Launch-Site Operations for a Space Vehicle

1. Booster unloading from sea-transport barge at dockside
2. Booster transport to launch pad
3. Upper-stage unloading from sea-transport barge at dockside
4. Upper stages checked horizontally in the staging building
5. Payload unloading and transporting to payload building for testing
6. Mating checks
7. Transfer of booster and stages to the launch pedestal
8. Vertical checkout (functional, over-all, prelaunch, calibration, alignment, simulated flight, flight safety).

second, and third stages are 3-in., 2-in., and 1-in. insulated lines, respectively.

Replenishing lox to the upper stages is controlled to exact level and maintained until umbilical separation during the launch countdown. The replenishing transfer lines for the upper stages are also routed through the umbilical tower.

The lox transfer system is automated and is initiated and controlled from the blockhouse propellant loading panels during transfer sequence. Prior to propellant loading, the system-components checkout can be accomplished at either the blockhouse or the lox complex.

The RP-1 fuel facility for the Saturn consists of protective revetments, foundation, and partial weather protection for the storage and transfer system. The system can service two Saturn launch pads from one storage facility, but at different intervals. A retaining wall to contain 125 per cent of the volume of the fuel tanks is provided with the reveted area to retain the fuel in case of tank rupture. The revetment wall is 15 ft high and is earth-reveted on the pad side. Fuel storage is facilitated by using two 30,000-gal-capacity, cylindrical insulated tanks. The transfer system and associated plumbing consist of a pad to support two 1000-gpm centrifugal pumps operating at 175-psi head pressure for fueling the booster, a 600-gpm recirculation pump, a 600-gpm filter-separator unit, an abductor system, miscellaneous valves, piping, and controls. The booster is serviced by two 1000-gpm pumps manifolded into 1000 ft of 8-in.-diam transfer line. Liquid level is controlled in the booster by a fuel tanking computer. The density of RP-1 fuel is monitored at all times by the fuel-density indicator. The fuel is overfilled in order that the fuel computer can adjust fuel level to 100 per cent by draining the fuel. The proper lox-fuel weight ratio at takeoff is accomplished by replenishing the lox to the proper level as dictated by the fuel.

Initial upper-stage fuel filling is accomplished through the same system but by utilizing only one 1000-gpm pump and a 6-in. line attached to the umbilical-tower structure. Once filled to the prescribed level, the fuel-transfer lines are evacuated of RP-1 by a jet eductor operating on Bernoulli's law of continuity.

Initial charging of the storage tanks is through the filter-separator unit to insure proper filtration of fuel and to minimize the entrained water content of the RP-1. During long storage periods, periodic operation of the filter-separator unit is required to insure desired fuel cleanness prior to vehicle servicing.

The fuel-transfer system is automated. It is initiated and controlled from the blockhouse fuel-loading panels. Prior to propellant loading, the fuel-system component checkout is accomplished at the blockhouse through the fuel loading panels. Communications between blockhouse and fuel complex is required during this operation.

Booster-Recovery Operations

Recovering the Saturn booster from the ocean is planned to be accomplished by the use of a fleet of surface vessels, including a Landing Ship Dock (LSD), four destroyer (or similar) escorts, two sea tugs, a PT boat, and a command-communications-helicopter-tender ship of a suitable type. Fixed-wing aircraft would be employed in spotting the downed booster.

The recovery operation will consist of four phases: (1) Location and damage surveillance; (2) recovery of the booster from the ocean; (3) decontamination and preservation; and (4) return shipment of the recovered components.

Immediately after booster impact, the helicopter and the PT boat would seek out the booster and keep it under surveillance until the remainder of the recovery fleet arrives at the impact site. Upon arrival at the impact area, the recovery fleet would deploy for the recovery operation.

With the aft deck of the LSD awash, the booster would be floated into position on fixed supports in the LSD well, and then the well pumped dry, leaving the booster in a supported position for decontamination and preservation.

Decontamination would consist of a dry air or LN_2 purge of the lox system, an over-all washdown with hot fresh water, and disassembly and cleaning of critical and special components. After decontamination, the booster and components would be thoroughly dried by purging with hot, dry air and preserved by the application of the desiccator breather assemblies.

The LSD would then return the booster to the appropriate dock (It is envisioned that this will be New Orleans) for barge-loading and return shipment to RSA.

As stated previously, dependent upon the magnitude of damage to the booster during the recovery action, the booster would be put either on a transporter or on supports used in the LSD. The recovered booster or salvaged components, deemed reusable by inspection specialists soon after recovery, would be transported from New Orleans to RSA by barge. There, unloading would be accomplished by roll-off of transporter, or when too heavily damaged, disassembly in barge and/or lifting the parts out of the barge by the available 20-ton crane.

The two tables here and the pie-wedge chart on page 80 summarize the general space-vehicle launch-site criteria, the launch-site operations, and the relative cost of the main items of a Saturn launch system. These simple outlines testify that we are indeed seeing astronautics become a major earth institution. ♦♦

IGY World Data Center Reports

Data and preliminary results from IGY projects are being issued regularly by the IGY World Data Center in two series of reports, one concerned with general information and one with rocket and satellite studies. Each report costs $1.00, postage prepaid. Standing orders may be placed for the series, which thus far includes six general reports and thirteen on rocket and satellite studies, with Printing & Pub. Office, NAS, 2101 Constitution Ave., N.W., Washington 25, D.C.

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Design notes

Prevention of Flashback Damage in Combustors

By R. C. Knauer and M. J. Webb

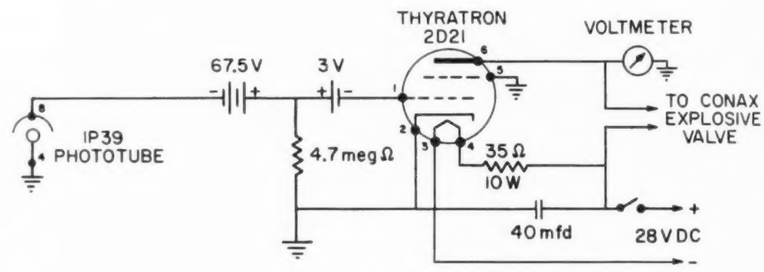
PRINCETON UNIV., PRINCETON, N.J.

The combustion of premixed oxygen and fuel gases often poses a problem of preventing combustion from taking place in the mixing region itself as a result of "flashback" from the combustion zone proper. When this flashback firing occurs, damage may result to equipment due both to pressure and heat-release, especially in combustors normally operating at high pressures. Pressure may easily be relieved with use of burst diaphragms, but the heat-release problem is somewhat more difficult. Under conditions of excess oxygen, not only does the gaseous fuel burn, but also the materials, including metals of which the equipment is constructed, may also combust. In systems having high mass flow rates of combustible fluids, human response times are inadequate to prevent combustion damage to equipment.

Flashback may be prevented under certain conditions, but because it depends upon many factors it cannot be known for sure that flashback will never occur. This is particularly true when the range of operating conditions are wide. Where the occurrence may be dangerous or expensive, the simple and reliable device described here may prove useful. It does not prevent flashback but eliminates combustion damage.

The device, diagramed below, consists of a rapid-response electronic trigger directly operating a Conax explosive valve. Upon receiving light from the combustion, a phototube triggers a thyratron, so that a condenser discharges to the valve igniter. The phototube is mounted on the equipment where combustion is to be prevented and views the region of interest through a shatterproof (Plexiglas) window. The explosive valve is placed in the oxygen line close to the mixing chamber. A total response time of less than 0.1 millisec is estimated for the device.

Since the explosive charge in the valve can be used only once, it is necessary to checkout the circuit with a resistor which simulates the valve igniter. A dummy resistor is connected to the output terminals in place of the valve and the circuit energized. The voltmeter now indicates the supply voltage. The phototube is exposed to a light source, and the thyratron should fire. Correct operation is indicated by a drop in voltage as shown on the meter.



Flashback-Sensing Device

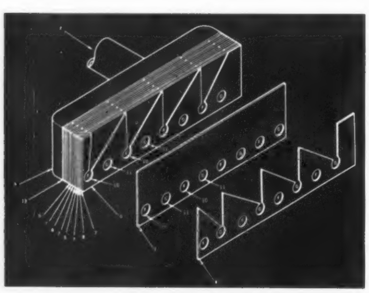
A Proposed Rocket-Engine Injector

By Lawrence J. Kamm

CONVAIR-ASTRONAUTICS, SAN DIEGO, CALIF.

The injector divides the fuel and oxidizer into very thin, flat, interleaved streams, and provides turbulence at the stream interfaces.

As seen in the illustration below, the injector is an assembly of thin laminations 6, 7, and 8 and manifolds 9 and 12. Laminations 6 discharge streams of fuel, laminations 8 discharge streams of oxidizer, and laminations 7 keep the streams separated until they have expanded to the full length of the laminations 6 and 8. The streams meet directly over the edges of laminations 7. Since the widths of the streams and of the spacing between streams may be of the magnitude of 0.005 in., complete mixing can occur within a very short distance from the surface of the burner.



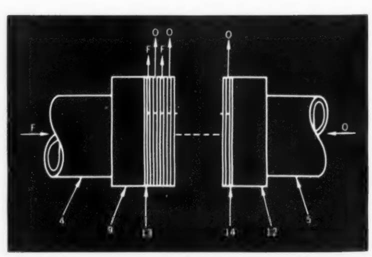
Exploded View

The shape of the notches in fuel laminations 6 and oxidizer laminations 8 are unsymmetrical, so that the emerging fluids have lateral components of velocity. These components are in opposite directions, and the crossed velocities contribute to rapid mixing. The diagram at the right indicates the interleaved sheets of emerging fluids.

The diagram at the left also shows the internal ducting of the fluids. Each lamination has an identical set of duct holes 10, 11. When the laminations are stacked, these holes align to form ducts extending the thickness of the stack. At one end, the fuel ducts 10 extend into fuel manifold 9 and at the other end the oxidizer ducts 11 extend into the oxidizer manifold 12, shown on the diagram at the right. The end lamination 13 has its oxidizer holes 11 omitted to separate the oxidizer ducts from the fuel manifold, and similarly end lamination 14 has its fuel holes 10 omitted to separate the fuel ducts from the oxidizer manifold.

The laminations and manifolds may be assembled by stacking and furnace-brazing. The parts may be pre-plated with brazing alloy to insure against voids. The laminations may be die-stamped or each type may be stacked and machined.

For corrosive fluids, such as fluorine, the assembly may be electroless nickel-plated (chemical nickel plate), which will deposit a uniform nickel coating in all recesses. Additional coolant ducts may be provided between the fuel and oxidizer ducts.

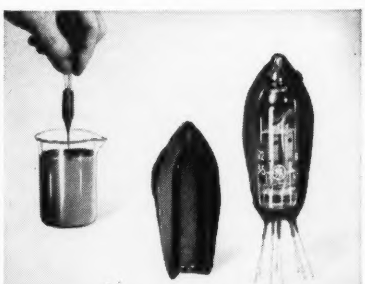


Side View

General Electric Silicone Rubber finds dozens of uses in missile systems. How many more will prove vital?

General Electric silicone rubber has the "thermal toughness" to stand up under the searing heat of rocket blast-off or possible atomic attack. Add very good electrical properties and excellent resistance to aging, weathering, moisture, flame, ozone and corona and you can easily see why silicone rubber is now being used in virtually every U.S. missile and space vehicle.

Since both space technology and silicone rubber are relatively new, General Electric believes there are many more areas not yet explored where silicone rubbers can help keep a missile functionally reliable and combat-ready. To help designers in their evaluation work, we list here the principal properties and applications of G-E silicone rubber.



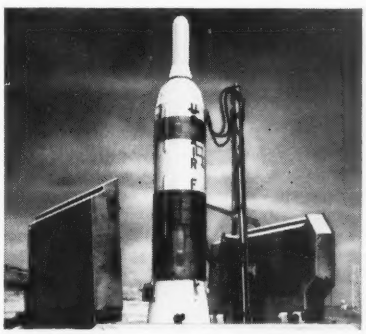
RTV LIQUID SILICONE RUBBER — One of the most versatile materials developed in recent years, RTV is a liquid rubber that cures at room temperatures. Like all silicone rubber, it remains flexible over a wide temperature range and is virtually ageless. Since it comes in a wide range of viscosities, it can be poured, sprayed, dipped, painted or applied with a pressure gun or spatula. It bonds tightly to metal when a primer is used. When not primed, you can readily remove RTV and then reapply more. You can impregnate tightly wound coils with RTV or form sections several inches thick.

You can control cure time from two minutes to 24 hours. These are RTV's typical properties:

Viscosity	from 120 poises (very pourable) to 12,000 poises (paste)
Specific Gravity	1.2 to 1.5
Solids Content	100%
Shrinkage	0.2%
Heat Resistance	from −90°F to 600°F, and as thermal insulation, in 5500°F flame for minutes
Ozone Resistance	Comparable to Mica
Electrical Properties	See last table

Applications—RTV is used as a high temperature structural sealant in missiles, satellites and space vehicles. It is used to pot and encapsulate electronic components and assemblies for electrical and heat insulation and for protecting delicate components from physical damage. It is commonly used as an impregnating insulation in transformer coils, to pot and hold cable in raceways and to pot cable breakouts. You can make flexible molds with RTV and hence make accurate, duplicate castings from originals.

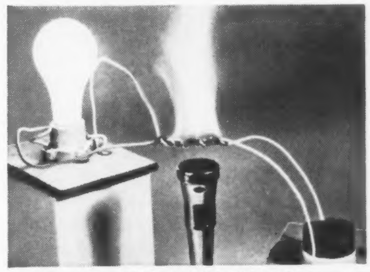
RTV is an excellent thermal barrier and as such is applied on and around missile nozzles. Tests show RTV's resistance to flame temperatures as high as 5500°F for several minutes. RTV also functions as a flexible ablative material and is used around probe holes, along raceways, and between stages and structural joints on the missile skin.



HEAT CURED SILICONE RUBBER PARTS —Silicone rubber gaskets, port seals, O-rings, shock mounts and other mechanical parts are not only used on missiles but have wide application in ground support equipment. For instance, missile silo doors use silicone rubber seals that will stand up to outside weathering, ozone and abuse for years and which will also resist the heat of missile launching and nuclear attack. Silicone rubber also resists brief exposure to cryogenic materials.

Silicone rubber has long-lasting temperature resistance from −150°F to 600°F, with excellent electrical, weathering, ozone, corona, radiation and nonaging properties at these temperatures. High tensile strength and low compression set are also within its range of desirable properties:

Tensile Strength, psi	800—1500
Elongation, %	100—600
Hardness Durometer (Shore A)	25—80
Compression Set, %	10—80
Tear Resistance lb/in	40—200
Radiation Resistance	1 x 10^8 roentgens
Electrical Properties	See table below



WIRE AND CABLE INSULATION — The long term reliability of silicone rubber when operating in high ambient temperatures and when current over-loads cause the conductor to approach 500°F is an important feature of silicone insulation. In an 1800°F flame, specially constructed silicone rubber insulated cables will continue to insulate for hours, forming a non-conductive ash that gives off no toxic fumes. And short term reliability is obtained even when silicone rubber is exposed momentarily to a direct flame of 5500°F.

Because of this excellent heat resistance, more current can be carried than in conventional cable (or smaller cable can be used). Other features: best compression set of all elastomers at temperature extremes, so that silicone rubber wire and cable does not deform under clamps; high ozone, corona, radiation and weather resistance, low moisture absorption, flexibility down to −100°C. These are the typical properties:

Volume Resistivity	10^{15}—10^{16}
Dielectric Strength, volts/mil	600—650
Dielectric Constant, 60 cps	3.0
Power Factor	.0010—.0050
Radiation Resistance	1 x 10^8 roentgens
Physical properties	Similar to table above.

Applications—Wiring harness made of silicone rubber insulation is often found throughout missiles. Cable offers added reliability for use in various places throughout the launch complex below ground from power plant to silos. All combat vessels built for the U.S. Navy during the last ten years, including fleet ballistic missile submarines and the new nuclear-powered cruiser and aircraft carrier, have silicone rubber insulated cable installations in all fixed wireways. In every case, silicone rubber is chosen because it is virtually non-aging, stands up to intense heat better than any other flexible insulating material, and continues to operate even when subjected to fire.

•

There are many more places where G-E silicone rubbers' inherent properties can be vital in missiles, satellites and space vehicles. For further data, call your nearest G-E sales office or write Section V1233 **Silicone Products Department, General Electric Company, Waterford, New York.**

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Astrobiology

(CONTINUED FROM PAGE 21)

essentially hydrogen, methane, ammonia, water, and helium.

According to modern astrophysical theories (H. Urey, G. Kuiper, L. Wild), the water molecules in this reducing atmosphere were split into hydrogen and oxygen by ultraviolet solar radiation (photodissociation). The lighter hydrogen escaped into space and oxygen remained. This initial oxygen oxidized ammonia to nitrogen (N_2) and water and, similarly, methane to carbon dioxide and water. With the appearance of chlorophyll-bearing plants (algae) about a billion and a half years ago, oxidization of the protoatmosphere was accelerated by the process of photosynthesis.

With this, biology entered the picture of the chemical transformation of the earth's gaseous envelope. In the course of millions of years, most of the atmospheric components became oxidized by the photosynthetically produced oxygen, and a large surplus of this vital element even accumulated. In the present-day atmosphere, this stock of free oxygen (O_2) amounts to 1.2 quadrillion metric tons.

Summarizing, we find in the historical development of the terrestrial atmosphere two basic types of atmospheres with pronounced chemical reaction tendencies and, logically, a transitional stage between the two:

1. *A reducing protoatmosphere.* In this anoxic hydrogen atmosphere, which was found in the early phase of the protoatmosphere, organisms are hardly conceivable. If, however, organic compounds such as amino acids were produced from methane, ammonia, and water by solar ultraviolet radiation or other photochemically effective rays with some CO_2 available (see later), anoxibionts could have existed in this phase of the protoatmosphere. These, then, would have been the protobionts on our planet.

2. *A transitional stage with increasing oxidizing power.* In this later stage of the protoatmosphere, chemautotrophs (iron-, sulphur-, ammonia-, and hydrogen-bacteria) and photoautotrophs (chlorophyll-bearing organisms of a lower order) could have existed. Large iron deposits, such as those found in the Great Lakes area, are the result of the activity of iron bacteria. These deposits are a billion and a half years old.

3. *A highly oxidized atmosphere with a large amount of free oxygen.* This type of atmosphere, which we observe today, provided the basis for the development of higher plants, animals, and man. We must keep in mind that behind this chemical transformation as the effective agent was, and is, solar radiation. The knowledge of this pattern of the historic evolution of the chemistry of the earth's atmosphere and the development of the biosphere (living world), and its active role in this process, gives us the necessary platform for a better understanding of the present-day atmospheres of the other planets and of their chemo-ecological qualities.

Let us now examine the chemistry of present-day planetary atmospheres.

Chambers for the study of micro-organisms under simulated Martian conditions at the Microbiological Section of the AF Aerospace Medical Center.

It can be assumed that the protoatmospheres of the other planets about $2^1/_2$ billion years ago had the same chemical composition as the protoatmosphere of the earth. It can then be expected that they should have very different properties now since they have been exposed to different intensities of ultraviolet solar radiation, corresponding to their respective distances from the sun. The planetary distances are such that each successive planet is about twice as far from the sun as the preceding one (Bode's Law).

The table on page 21 shows the main chemical components of the planetary atmospheres in the order of their abundance. We find, in the solar planetary system in its present state of development, two basic types of atmospheres:

(1) Hydrogen and hydrogen compounds containing atmospheres on the outer planets (from Jupiter to Pluto).

(2) Oxygen and/or oxidized compounds containing atmospheres on the inner planets. These are of three varieties: The densely oxidized terrestrial atmosphere with a high free oxygen content; the densely oxidized Venusian atmosphere with no oxygen or only a small amount of oxygen; and the thinly oxidized Martian atmosphere, also with only a few traces of free oxygen.

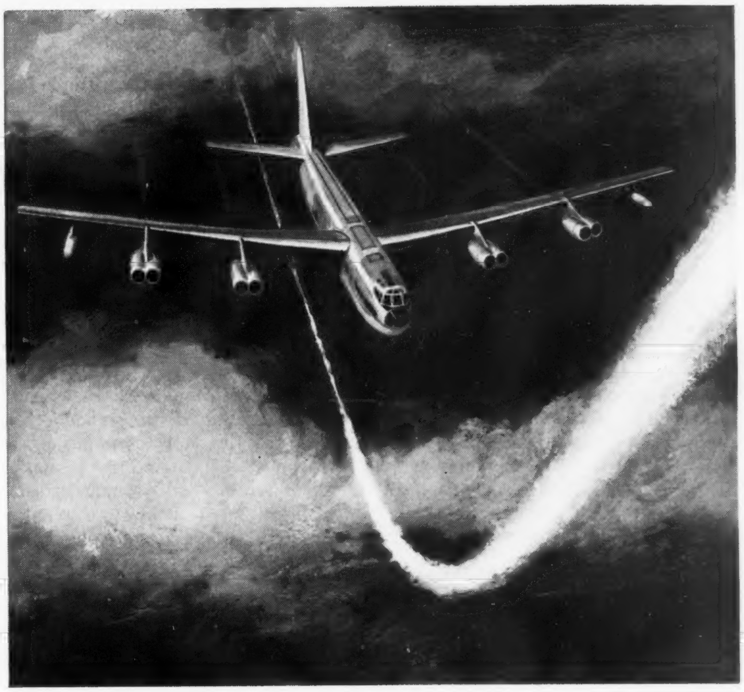
Oxygen and Hydrogen Belts

The group of oxygen-dominated atmospheres of the inner planets represents a kind of *oxygen belt* in the planetary system, with the earth as *the* oxygen planet, while the group of hydrogen-dominated atmospheres forms a *hydrogen belt*. These two belts correspond exactly with the two basic phases in the historic development of the earth's atmosphere: The hydrogen phase some $2^1/_2$ billion years ago, and the present oxygen phase. The atmospheres of the outer planets, while beyond the photochemically effective range of solar ultraviolet radiation, apparently have remained in a sort of protoatmosphere phase up to the present time.

It is interesting that there is no intermediate type of atmosphere in the planetary system. This can be explained through the existence of a wide spatial gap between Mars and Jupiter.

So much for the chemistry of the atmospheres of the planets. They all belong to the same family of celestial bodies but revolve around their central body—the sun—at different distances and as a result show a different chemistry which is ecologically significant.

No less significant for life is the



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temperature of the planetary atmospheres, which, too, is dependent on the solar distance. Temperatures on planets which are favorable to life are found only in a certain solar distance range, as shown in the illustration on page 21. We can call this zone the *biotemperature belt* in the planetary system. Venus lies in the warm, or hot part of this belt; Mars in the cool, or cold part; and the earth in the golden middle of the belt. The outer planets, with temperatures ranging from −140 to −250 C, lie outside this belt of life-supporting temperatures.

The Liquid Water Belt

In about the same area, dependent on the temperature, water is found, or is conceivable, in its biologically useful form, that is, in the liquid state. Harlow Shapley calls this zone the *liquid water belt* of the planetary system.

And, as we have seen, we can also speak of an *oxygen belt* in the planetary system which includes oxidized compounds, such as carbon dioxide.

With regard to light conditions, another important ecological factor, we may also speak of a *euphotic, or biophotic, belt*. All these belts are found at about the same distance from the sun.

To cover all these ecological factors, we can use, for this life-favoring zone, the more general term of planetary system *ecosphere* or helio-ecosphere. This ecological belt, or zone, of the golden orbits is a relatively narrow zone and represents less than 5 per cent of the whole range from the sun to Pluto. In this belt, total solar irradiance ranges from roughly 4 to 0.5 cal cm^{-3} min^{-1}, and solar illuminance from 270,000 to 40,000 lux (= lumen per square meter). For comparison, the corresponding values on the earth's surface reach, maximally, 1.4 cal cm^{-2} min^{-1} and 108,000 lux, respectively. The concept of the ecosphere, also referred to as the "habitable zone," has recently been applied to other stars by J. Gadomski, H. Shapley, and others. In such a comparison, our solar system can serve as an astrobiological model for other stellar ecospheres, just as we used the earth previously as an astrobiological model for other planets.

Returning to the solar system, from all our general ecological considerations, it seems to follow that, in addition to earth, only Mars and possibly Venus can qualify as bioplanets.

On the outer planets, micro-organisms, such as hydrogen or methane bacteria, etc., are conceivably just the same as in the terrestrial protoatmosphere if the temperature on the surface is within physiological limits.

Of the ecospheric planets, Venus, constantly and completely covered with dense clouds, probably consisting of carbon dioxide crystals, is shrouded in mystery insofar as surface features are concerned. The thermal environment of this planet might be on the hot side due to its close proximity to the sun and a "greenhouse" effect in its CO_2-enriched atmosphere.

The Martian atmosphere is rather transparent, and permits observation of the planet's surface. Because of this, *Mars* is the favorite planet for astrobiological discussions and has been since Schiaparelli's description of the canals and the observation of dark green areas which show seasonal color changes of the kind observed in terrestrial plants. These have recently once again become the subject of intensified study as a result of improved spectrographic techniques and the possibility of transatmospheric observations from balloons.

There are three theories concerning these dark green areas on Mars: (1) The organic, or vegetation, theory; (2) the inorganic theory, explaining them as the result of either volcanic eruption (P. McLaughlin) or of color changes of some hygroscopic inorganic material caused by variations of the soil's humidity (S. A. Arrhenius); and (3) the physiological optical theory, which explains the green color as a contrast phenomenon against the yellow-red surrounding area.

The following discussion is confined to those theories which involve biological or physiological aspects of the problem.

Concerning the vegetation theory, some climatic data must be considered. Oxygen is present on Mars only in traces, the carbon dioxide pressure is considerably higher than on earth, and nitrogen is abundant. Water, however, is very scarce. The light intensity is about 40 per cent of that on earth—high enough for photosynthesis as we know it. The amplitude of the day-night temperature variations in the equatorial regions can exceed 70 C. During the day, temperatures can reach 25 C, but these drop during the night to −45 C and lower.

In general, then, the physical conditions are, in terms of terrestrial botany, extremely severe with the exception of sufficient carbon dioxide and light, and suitable temperatures, during the day. Such conditions, by terrestrial standards, could support only very hardy and cold-resistant organisms.

But we must consider not only the climate as a whole, but also the so-called microclimate, near, on, and below the ground, and influenced by surface and subsurface features, such as snow covering, hollows, caves, etc., which usually moderate the extremes of the macroclimate.

And then we must not only look upon the physical ecological side of the problem but also upon its physiological side—that is, the enormous capacity of life to adapt itself to abnormal climatic conditions. With regard to the specific environment on Mars, we should consider the possibility of adaptive phenomena such as storing of photosynthetically-produced oxygen in intercellular spaces, as we sometimes find in the leaves of water plants; storing of carbon dioxide in tissue fluids; storing of water, as in our desert plants; stronger infrared absorptive power of plant surfaces; and a shift in the reflecting power toward blue for temperature control, as has been found in our subarctic plants. Protection against frost could be imagined if Martian plants were able to produce some kind of antifreeze, such as glycerol, as a metabolic byproduct. When searching for clues in the botanical literature, I have found that some of our terrestrial lichens *de facto* contain erythrol, which belongs to the same class of chemicals as glycerol.

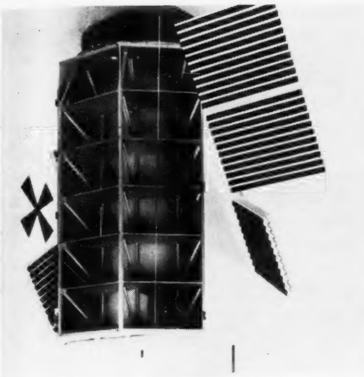
What are the results of observational and experimental studies?

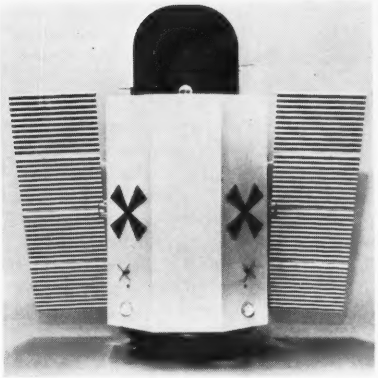
William M. Sinton of the Smithsonian Observatory found strong absorption bands near 3.4 μ, the wavelength of the carbon hydrogen bond. This indicates the presence of organic molecules. Dr. Sinton emphasizes that this organic material would easily be covered by dust from storms, unless it possesses some regenerative power. A strong regenerative power was first postulated by E. G. Oepic.

Andouin Dollfus of the Mendon Observatory in Paris, along with L. Focas of Athens, Greece, made polarimetric and photometric observations on Mars and, for comparison, on mixtures of dirt and plant material. His results, too, favor the vegetation theory.

Russians on Mars

In Russia, the outstanding Mars researcher was the astronomer G. A. Tikhov at the Alma Ata Observatory. He studied the optical properties (reflection and absorption) of terrestrial plants and compared them with those of the dark green areas on Mars. He could not find the main absorption bands of chlorophyll in the spectrogram of the dark green areas, in conformity with G. Kuiper. But he found strong absorption in the infrared. He observed the same thing in plants growing under severe conditions like those found on the Pamir Plateau in South Central Asia and in the subarctic. He advanced the opinion that,





OAO–Eye in the Sky

Models, the one at left cut away to show an interior view, exhibit the $1^1/_2$-ton Orbiting Astronomical Observatory satellite which Grumman Aircraft will develop for NASA under a contract for about $23 million. The OAO will have telescopes with mirrors up to 36 in. and other instruments for studies in ultraviolet and infrared light. Two flight models will be built under the contract, and NASA plans to make the first launching in late 1963, with an Atlas-Agena B going for a 500-mi circular orbit. The design features a titanium-skinned body enclosing an aluminum-frame interior structure. Solar-cell paddlewheels will generate about 350 w. The crosses are some of the several antennas.

the colder the climate, the less the reflecting power of plants in the main heat-carrying rays from infrared to red and yellow. Optically, this means that their color is shifted to the bluish side. Ecologically, it means that they absorb more heat.

Since the dark areas on Mars show a strong bluish-green tint, the plants on Mars may have developed just these optical properties for adaptation to the severe Martian climate. All these properties, manifested in the color of plants, are essentially adaptations to the general level of the environmental temperature. On Mars, therefore, where the climate is vigorous, the plants are of blue shades. On earth, where the climate is intermediate, the plants are green, and on Venus, where the climate is hot, the plants have orange colors—according to Tikhov. He first published his findings and conclusions in books entitled "Astrobotany" (1947) and "Astrobiology" (1953). He also founded a Department of Astrobiology with an astrobotanical garden at the Alma Ata Observatory.

Another Russian scientist, Olga W. Troizkaya, is not so optimistic, and gives only anerobic, very cold-resistant micro-organisms, a chance for existence in the Martian climate.

Most astrobiological researchers are in favor of the vegetation theory. Nevertheless, the problem of the green areas on Mars is far from solved, and it is especially difficult to explain their rapid expansion in the Martian spring. Following the melting of the icecaps, they progress toward the equator with a speed of five to 10 miles per day. No such growth rate is known to us in the terrestrial plant kingdom, as has been emphasized by Frank Salisbury. Perhaps one could explain it by a sleeping, drooping position of the leaves during the winter—almost a kind of hibernation. Then it might be imagined that in spring the leaves expand in a horizontal position and are fully exposed to sunlight and to the eye of the astronomer.

Martian Colors

But the human eye as such also requires attention in the astrobiological evaluation of the dark green areas. Is the green coloration of Mars real, or is it only a contrast phenomenon? First of all, observation of the green areas on Mars requires normal color vision in the observer, as has been emphasized by Ingeborg Schmidt of Indiana Univ. The same author made experimental studies with gray patterns of different forms and sizes on a yellow-red background, and came to the conclusion that some of the green colorations on Mars are probably contrast phenomena, especially if the areas are small. This conforms with the earlier observations of G. Kuiper who, with great magnification, found traces of moss-green colorations when observed with the peripheral retina. When observed centrally, the areas appeared as dark gray. But whether the areas are green or are not green, the possibility that vegetation exists on Mars cannot be excluded.

All the above shows that the question of whether life exists on Mars is at present the focal point of a host of theoretical, observational, and experimental studies. However, it may well be that the final answer will not be available until the first astronaut sets foot on this "red," or "red-and-green," or "red and apparently green" planet, and telemeters his findings down, or up, to his home, or not-any-longer home, planet earth, to the delight or disappointment of the proponents of the various Martian theories.

Mars in the Laboratory

A new experimental line of astrobiological studies is that of examining terrestrial micro-organisms under simulated Martian conditions in Mars chambers, as carried out in the Department of Microbiology at the AF Aerospace Medical Center. These studies indicate that certain kinds of soil bacteria perish; others, however, not only survive but increase in numbers during exposure to an environment in which most of the Martian atmospheric conditions (air pressure, composition, and temperature) are reproduced. Such experiments, which should be extended to Venus and Jupiter chambers, are not only of astrobiological interest, but also of general biological interest, insofar as in this way the "struggle for existence of life," as conceived by Charles Darwin, is shifted from a terrestrial to a cosmic level. They are also of significance with regard to contamination of other celestial bodies by terrestrial organisms, and vice versa. This subject may become an important subfield of astrobiology.

Astrobiology, of course, is also interested in the question of the origins of life. In this respect there are two theories. The first of these is the panspermia theory, according to which micro-organisms are distributed through space under the effect of light pressure, or by means of meteorites as carriers.

Another theory suggests that life originated on the individual planets. Concerning earth, it has been theorized that in its protoatmosphere, containing hydrogen, ammonia, methane, and water vapor—some $2^1/_2$ billion years ago—organic compounds such as

amino acids were produced by ultraviolet solar radiation, cosmic rays, or by lightning and settled down in the oceans which turned them into a kind of organic "nutritional soup." This pre-biotic material is considered to be a pre-condition and pre-stage for the origin of life. That such photochemical or electrochemical reactions occur was verified six years ago by means of an electrical discharge in a chamber containing the gas composition of the primordial atmosphere (S. Miller).

The discovery of the Van Allen belt suggests that the particle rays trapped in the geomagnetic field may have played an important role in this respect. The horns of the outer radiation belt, which dip considerably into the atmosphere in the subarctic latitudes, manifested in polar lights and increased temperature, may have been especially effective locations for the production of pre-biotic material, particularly after solar flares. Such an assumption would also be of interest with respect to the possibility and origins of life on other planets. The inclusion of the geomagnetically-produced radiation belt, in addition to solar ultraviolet radiation, in the problem of the origins of life at protoatmospheric times, offers a promising platform to the physicist and biologist for theorizing and experimentation.

In conclusion, one might well ask: "But what's the use of these astrobiological studies?" The simplest answer is that they will be beneficial to general biology!

As an example from the inorganic world, helium was discovered in 1876 in the spectrogram of the sun, from which it obtained its name, and it was thought at first that this was an element found exclusively in the sun. Some 20 years later, it was discovered on earth as well. In the same way, by studying the planets, by looking at the green areas of Mars, and by studying their absorptive, reflective, and other properties, we may discover things that have been overlooked in terrestrial biology and botany.

Only through the extension of our biological thinking into the cosmic spectrum will our knowledge and efforts in the life sciences become complete.

A complete list of references for this paper may be obtained by writing to the Editor, *Astronautics*, 500 Fifth Ave., New York 36, N. Y. ♦♦

A top expert on Russia tells why the Soviets lead in rocketry — and how we can close the gap now —

RUSSIA'S ROCKETS AND MISSILES

by Albert Parry

Contributing Editor, *Missiles and Rockets*

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Satellete Motion Simulator

(CONTINUED FROM PAGE 23)

part of this article, there will always be some remaining unbalances. This is not detrimental to the functioning of the simulator as long as the torque due to the unbalance can be held at a level of at least two magnitudes below the maximum control torque available. Unfortunately, this maximum torque is very small, which, in case of the described simulator, calls for an upper limit of 5 gr-cm (smaller than 0.1 in-oz) for the unbalance at any deflection angle. Two examples will illustrate the extreme smallness of this torque: If the center of gravity of the platform shifts more than *one hundredth of the diameter of a hair* (5×10^{-6} in.) away from the perpendicular through the center of rotation, the 5 cm-gr is already exceeded. Or, if a *paper match* is placed on an extreme part of the platform, the allowance for the unbalance is also exceeded (compare the weight of 900 lb of the platform with the weight of the paper match).

The angular freedom of motion of the spherical air bearing is ±120 degrees in two axes (pitch and roll) and unlimited freedom in the third axis (yaw). This is approximately the maximum which can be achieved without having all control equipment contained within the air-bearing sphere itself. This freedom was made possible by a support arm which can be moved out of the way during operation of the simulator.

The drawing on page 23 shows some detail of the air-bearing construction. The air-bearing sphere, which has a diameter of 10 in., was manufactured to a tolerance of 0.00005 in. This small tolerance still introduces an unbalance up to 60 cm-gr which exceeds the requirement for the simulator by a factor of 12. This, as well as other predictable unbalances, can be eliminated by the use of compensation devices which are described later under the heading "Anisoelasticity-Torque Compensation."

The sphere is resting on an air cushion in a cup 6 in. in diam. The cup has tiny holes (arranged in two concentric circles) which permit the pressurized air to form this air cushion. The air escapes at the periphery and at the center of the cup. The center vent increases the stability of the bearing; no tendency toward self-sustained oscillations can be observed. The air gap is approximately 0.002 in. at a supply pressure of 100 psi. The air consumption at this pressure is almost 1.5 standard cfm.

To prevent galling of the air-bearing surfaces, a metal-to-metal contact has to be avoided when the air pressure is cut off. For this reason, the cup is built like a piston in a pneumatic cylinder, and is held in the upper position by the air pressure. When the air pressure is turned off, a spring pulls the cup down and the sphere settles on a nylon ring. Thus, a metal-to-metal contact between the sphere and the cup is prevented.

Platform Balancing

The balancing is done by observing the changes in position of the platform. Before each balancing test, the platform has to be brought to a complete stop, because, with the small magnitudes involved, it is impossible to distinguish between the position change due to unbalance and the one due to an initial velocity. A "brake" was installed to prevent an initial velocity. It consists of metal bellows with a rubber pad at the top end and is located in the center of the cup. During normal operation, the rubber pad is not touching the sphere. If air pressure is fed to the bellows, they expand and press the rubber pad against the sphere. Only a small portion of the weight of the platform is supported by the pad and the normal operation of the air bearing is not affected. The pad is secured against rotation and lateral motion, and therefore brings the platform to a complete

stop. Release of the pressure in the bellows frees the platform without introducing an initial angular velocity.

The platform is constructed of sheet metal welded together. To achieve maximum rigidity, the box design is used whenever possible. The platform was heat-treated to relieve stresses and thus minimize the possibility of warping after machining. The box design created many enclosed compartments. These compartments were filled with Eccofoam FP to prevent chips or other loose material from moving around and disturbing the balance.

Method of Construction

To avoid unbalances due to temperature changes, it would be necessary to construct the whole simulator and its control equipment with homogeneous material. This is impossible. Manufacturing considerations already necessitated such a difference in the coefficients of the sphere plus the shaft (which is one body) and the platform that an unbalance of roughly 40 cm-gr/deg F was measured.

A simple but effective temperature-torque compensation solved this problem. A nylon strip is sandwiched between the side plate of the platform and a steel strip. One end of the nylon strip is rigidly attached to the side plate, the other to the steel strip. The temperature expansion coefficient of nylon, being quite large, causes the center of gravity of the steel strip to be moved relative to the side plate. By proper orientation of the whole arrangement, the unbalance due to temperature changes can be compensated. A total of four arrangements are used. Adding more weight or less weight to the steel strip allows matching of the compensation with this unbalance.

A temperature sensitivity of less than 2 cm-gr/deg F can be held. Since the temperature of the environment can be kept within ±1.0 deg F during one test, the residual unbalance due to temperature changes no longer presents a problem.

All predictable unbalances, except the effects of temperature changes mentioned before, can be treated in combined form and their relative magnitude need not be known. For the described simulator, however, aniso-elasticity provided over 90 per cent of the unbalance. The unbalance torque as a function of the deflection angle of the platform for the three axes is shown on page 22. The position with the platform being level was chosen as the reference for the deflection angle. Yaw was measured after an initial roll angle of 90 deg. The curves include the influence of the tolerance for the air-bearing sphere. No control equipment was mounted on the platform.

Simulator Characteristics*

A. Platform

Weight, lb	900
Dimensions, in.	
Length	55
Width	26
Height	35
Moments, m kg sec^2	
Pitch	9
Yaw	9
Roll	4.5
Angular freedom, deg	
Pitch	±120
Yaw	Total
Roll	±120

B. Air Bearing

Diam of sphere, in.	10
Diam of cup, in.	6
Lift-off air pressure, psi	50
Air gap,** in.	0.002
Air consumption,** cfm	1.5

* Approximate values

** At 100-psi supply pressure

Since every control component attached to the platform changes the characteristics of the unbalance, an easily adaptable solution to the problem had to be found. Two compensation devices for each axis, like the one shown on page 23, provided all the desirable features for easy change of magnitude of the compensation-torque curve. Theoretically, compensation devices for two axes would have been sufficient; but tests showed that compensation for all three axes simplified the adjusting procedure for the compensation devices. Each of the compensation devices consists of a slidable mass on a cantilevered leaf spring which bolts to the platform.

There are several possible ways to vary the amplitude of the compensation torque, such as by change of the spring constant, by change of the weight attached to the spring, and by change of the tilt angle β of the undeflected leaf spring, as shown in the photo on page 23. By shifting the center of gravity of the platform, it is possible to compensate for torques in the horizontal and vertical positions of the platform. The spring-mass devices produce a compensation torque which in a first approximation varies with the sine of twice the deflection angle of the platform. Actually derivations of the compensation characteristic from the sinusoidal shape occur for large leaf-spring deflections. This effect can be used to change the shape of the compensation characteristic for further adaption.

Limits of CG Shift

The center-of-gravity shift of the control components as a function of the deflection angle should be as small as possible, which indicates that all electronic equipment has to be packaged rigidly. Abrupt center-of-gravity changes (e.g., lateral play in ball bearings) have to be avoided because there is no compensation possible. The batteries have to be of the dry-cell type. The information from the control system has to be telemetered out, since any kind of mechanical connection would introduce too much unbalance or friction torques. Containers for usable fuel (e.g., air bottles for gas-nozzle systems) have to be mounted so that, initially, the center of gravity of the fuel coincides with the center of rotation of the platform. During consumption of the fuel, its center of gravity must remain fixed.

Acknowledgment

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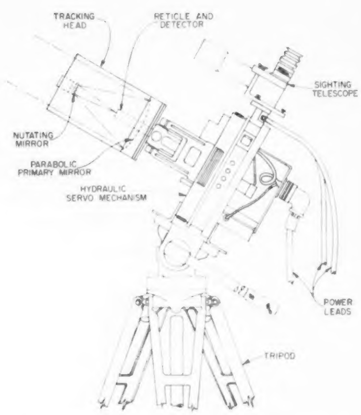

Raytheon Tracking Instrument Follows Satellite Tumbling

Engineers man the tracking instrument illustrated at left, developed by the Raytheon Co., and demonstrated recently to station chiefs of the Smithsonian Astrophysical Observatory's worldwide tracking network. The instrument gives immediate and continuous data—course, bearing, and attitude—on a satellite as it tumbles. The primary mirror is 6 in. in diam. Such a tracking instrument might have an important role in reporting on the attitude of manned orbiting spacecraft and directive-antenna satellites.

GSE Different Approach

(CONTINUED FROM PAGE 34)

measure, repair, overhaul, assemble, disassemble, transport, safeguard, record, store, actuate or otherwise maintain the operational status of the airborne vehicle.

This definition was written by persons with maintenance as a primary function and was written from a support point of view. Equipment developed and placed in the inventory to accomplish all of the functions mentioned is very necessary, but none of these maintenance functions take place during a missile launching. Equipment such as the launcher, propellant loading and pressurization system, launch-control equipment, and guidance perform functions other than those defined or described. This equipment has to be defined and designed as interrelated systems to perform the many functions necessary for a successful launch in the same fashion as the many systems carried aboard the missile. Also, to achieve the optimum design, and to achieve an efficient weapon system design, this equipment should be designed in conjunction with the missile and not subsequent thereto.

In evaluating the total problem of weapon system design, it became apparent that this class of equipment must be treated separately from GSE. This equipment is to the missile system what the cockpit is to the airplane. Military Specification MIL-D-9310A described this class of equipment and titled it "Ground Co-operating Equipment." For the Titan program the title was reduced to Ground Operating Equipment (GOE). The definition is as follows: Ground Operating Equipment (GOE) is equipment which is a functional part of the weapon system or support system and which operates with the prime air vehicle in the performance of the latter's mission as a major operational element of the weapon system or support system. This term does not include items defined as GSE.

In June 1958, after approximately six months of effort had been expended managing the development as GSE, it became apparent that to achieve an optimum design we could not continue in this fashion. Therefore, the contractors were briefed on the new engineering and management concepts involved and the program was re-oriented, so that the design of GOE could and would be made in conjunction with operational missile design. This design and development concept has resulted in GOE simplification and has increased recognition of the parallel efforts and controls required to obtain a successful design.

GOE design, development, and testing are now carried on in conjunction with the missile design, development, and testing. The equipment systems are controlled by model specifications; end items are controlled by detail end-item specifications; and tests of GOE are carried out in conjunction with the missile test program. We have achieved an integration of missile and ground-system design, with the whole considered and managed as one development and test program.

In the design of an ICBM weapon system or a space system, the GOE design requires as much if not more engineering talent than the design and development of the airborne vehicle, and should in fact be considered as part of the airborne systems. The stringent reaction times levied on ICBM's today make it almost impossible to consider a missile design without concurrently considering GOE design, and we must remember that the launch countdown is not a maintenance function. The GOE design criteria for automation, reliability, and ruggedness are as stringent as those used by the missile designers. To achieve a fast reaction or launch time we must have a reliable system. We therefore spend the necessary effort to provide this. Also, the GOE and missile designs should be done as one major system interfacing only at the umbilical tower through the umbilicals. If GOE design efforts are handled in this fashion, the equipment is automatically identified by subsystem and system because of the functions performed. In the days of aircraft, no one designed the cockpit and the aircraft separately, nor were these design efforts managed differently.

GOE vs. GSE

A critical examination of the functions performed by GOE will reveal that none of them overlap the definition applied to ground-support equipment. The first example is the launcher system. It holds the missile in a launching position and provides the support for the umbilical tower and service lines for pressurization, pneumatic control, hydraulics, and rapid propellant loading when we have cryogenics. These are functions or support for functions accomplished during the launch operation and their use for maintenance is only incidental in that the design criteria for the launcher are primarily determined by the operational launch conditions.

The second example is the ground-

guidance equipment. It is used only during the flight of the missile, and its function there is guidance and control. We would not classify a GCI radar as GSE. Therefore, neither can we so classify the missile ground guidance.

The propellant transfer system as GSE has to do chiefly with cryogenic missiles because it is never used as a maintenance tool and its probable function is to store lox and on command transfer it to the missile during the launch operation.

The last example is the launch-control equipment. In the Titan program, we have combined the launch-control and checkout equipment to better optimize the design. Also, when the missile design was evaluated concurrently with the ground-equipment design, many of the same steps used to count down the missile could also be used for the checkout function. The primary design criteria for this equipment, though, are determined by the operational launch requirements and were not determined by maintenance requirements.

The launch-control-and-checkout-equipment design is as much an integral part of the design of the missile as the cockpit of an aircraft is an integral part of the design of an aircraft. If the functions performed are carefully analyzed, we find that the functions required of the launch control and checkout equipment are almost identical to those required of the aircraft cockpit.

During a launch countdown the missile's related equipment is cycled through a series of steps necessary to successful flight. The number and complexity of these steps are determined by the reliability of the systems, the limits of reaction time placed on the system, and the environment from which the system operates. These operations are not maintenance functions per se, but they may create maintenance activity. As an example, the flight-control system on the missile might fail in one of the steps necessary to get it warmed up and operating during the countdown. This failure, then, has created a maintenance effort. Admittedly much of the launch-control equipment will be used to check the flight-control system to determine which unit must be replaced, but this is no different than using the magneto swiches on an aircraft to determine which magneto has failed and must be replaced. After the replacement action has been accomplished, the flight-control system will be put back through its countdown steps with the launch-control and checkout equipment as an installation verification prior to continuing with

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the remainder of the countdown.

The only maintenance action involved so far has been the removal and replacement of the failed unit. The rapid reaction limitations and stringent airborne-environment conditions make removing and replacing actions necessary instead of repair in place, but this is nothing new.

After the failed item has been removed from the launch complex to the maintenance area in the squadron, this piece of the flight-control system will be checked for the failed component. We now see that this is the first time in this operation that a piece of GSE has been used. For this trouble shooting on the bench back in the squadron maintenance area, we plan on using as much standard test equipment or standard GSE as possible.

During the design phase, when the design of the missile and its accompanying GOE are being determined, based on the functional requirements of the missile, an optimum design can be reached only in considering the GOE as a true extension of the airborne subsystem. In this fashion we achieve a truly integrated design for the missile and its launch equipment. At first this may not seem to be important to some people; but later on, as a program grows, the importance of this initial step begins to become apparent. Under the concurrency concept the flight test and the development programs are carried on in conjunction with the design for the operational squadrons and the design for the operational equipment.

In order to control the design and configuration of the operational equipment, the missile and GOE design should be considered as one design. An example of the need for this is the Titan Activation Schedule. We are flight testing missiles from Cape Canaveral, putting the first operational prototype unit together at Vandenberg Air Force Base, finishing the installation of the first training facility for the Strategic Air Command, and activating the first operational squadron. The launch-control and checkout equipment and the remainder of the GOE must be installed at the sites just mentioned as much as 6 to 8 months in advance of the missile delivery to these sites. As you can see, this creates a tremendous problem in configuration control, a problem almost unsolvable if the GOE were treated other than as a complete design package. Also, standard management and control procedures as exercised for GSE has never resulted in a system design, and has never created an optimum design which could be delivered prior to the delivery of the airborne vehicle.

How to Boost 10 Lb 200 Miles into Space

Use Rocket Power/Talco's Phoenix sounding rocket, shown above, which did just that recently, as the culmination of the company's development program for the Univ. of Maryland and S. Fred Singer's ionospheric-study group. The two-stage solid-propellant rocket measures 18 ft long and weighs 300 lb. Both rocket and launcher look very trim and easy to handle.

It has also been proven that precise management cannot be applied to all items in the inventory. Spreading the management effort too thin actually results in managing nothing.

The design of GOE as well as design of the missile creates maintenance functions and must be supported by GSE. However, the design of the missile and accompanying GOE can be controlled such that GSE does not have to be peculiar. In the area of electronic test equipment, certain items such as oscilloscopes or vacuum-tube volt meters can check any electronic circuit. The same thing applies in general to hydraulic systems, pneumatic systems, and to some extent to cryogenic systems. The only things involved in the hydraulic, pneumatic and cryogenic systems are fitting adapters to be used on standard test benches that have been developed in support of aircraft programs, and some better cleaning devices. In the ground-handling area, some peculiar equipment had to be designed and developed, but in most cases this was an adaptation of a commercial article already in existence some place within the U.S.

We in the Titan program have placed automatic equipment within the GOE only because of the countdown and reaction-time limitations and because of the number of checks which must be made during the countdown prior to a missile launch. We have also looked at automatic equipment with a view toward relieving the human operator of those actions that he is least capable of doing without making a mistake. As you know, the human being is a good integrator provided he has the time to do the integration and can concentrate on only two or three things at a time. This creates a necessity for automatic countdown equipment. This also applies to the ground-guidance and control equipment, because things happen so rapidly here in so many varied ways that a human operator or a bank of human operators could not possibly do the guidance and control as well as a piece of reliable automatic guidance and control equipment.

Functions Analyzed

In the ballistic-missile programs, and in particular the Titan program, we had to analyze the functions to be accomplished at each phase of the operation, from factory through launch. All functions performed from the factory to the launch complex—in fact, up to the condition of missile and facility readiness—were maintenance-related, and those functions performed beyond this condition were all launch-related. These latter functions, the countdown, were all maintenance-generating functions. Also, to satisfy the stringent reaction time imposed on the weapon system, each major element had to be designed for rapid replacement of components if failure occurred.

With these design criteria in mind, all replaceable elements are removed to a repair facility for repair and return to the serviceable inventory. With reasonable reliability and spares support, then, there is no real need for a very rapid repair and return. Therefore, the Titan program has practically no automatic GSE. Instead, we use Air Force standard test and repair equipment. Also no one can afford automatic GSE unless it can be kept busy. In fact you cannot afford to have any equipment that is not used. In the Titan program we have fewer than 120 items of peculiar GSE, out of a total of approximately 1000 GSE. As evidenced here, one of the major GSE design criteria was that it must be as much as possible independent of missile and GOE equipment configuration.

Up to this point I have covered the initial operational development for the Titan program. We have concentrated the automatic equipment (GOE) where it was necessary to meet reaction-time limitations and in the guidance and control functions. In future developments, the GOE will continue to be automatic. However, the GSE for future systems need be automatic only if repair times are drastically cut or if more repair and trouble shooting can be concentrated for service by automatic equipment. No factory producing only a few units per day can afford to have automatic equipment on the production line—it costs too much!

The problem of reliability has always been one about which much has been written and many theories advanced. I firmly believe, and I think it can be easily shown, that the reliability of any piece of equipment is determined basically by the design and the selection of components that make up the finished article. The reliability of our standard GSE is satisfactory for its intended purpose. However, the reliability of the automatic GSE developed within the past two or three years has not been as good as it could have been. This stems from two main causes: One, overcomplication, and two, hurried development.

In the area of GSE, I cannot see that there will be much difference in the decisions or assignments delegated to technicians versus machines except at the factory or depot level. For organizational maintenance the technician will still play a very important role in any repair action. We cannot afford to give the squadron a piece of automatic checkout equipment to trouble-shoot an amplifier, control circuit, or radar transmitter, because, in the first place, there is not enough work to keep the machine busy and, in the second place, the checker has always been several times as complicated as the item being checked. Also, all troubles cannot be card-indexed.

However, in the area of GOE, as I pointed to in the Titan program, all decisions which can be handled by a simple logic circuit will be assigned to the equipment. This method of assignment will give the man time to make a decision in those areas where a simple *yes* or *no* will not suffice. These simple criteria also work quite well for manned space flight. An example of this is the re-entry control mechanism for the Project Mercury capsule.

The area of standardization is one which has caused a lot of concern in the past and will continue to do so in the future. There is no reason why we should not continue standardization of GSE for all weapon systems. We have standardized over 80 per cent of GSE in the Titan program. "Universal" GSE, as some has been advertised, is primarily that designed for depot or factory usage. Standardization within the area of GOE is like trying to standardize on one flight control-system design for every missile. However, there is standardization of components within the flight-control systems.

Since GOE is an extension of the airborne system, standardization is quite difficult except for components, because each airborne system or subsystem is designed to satisfy the requirements of the particular vehicle. As an example, the Atlas flight-control system will not satisfy the requirements of the Titan missile, even though both are ICBM's. However, the GOE for the re-entry vehicles used on Titan and Atlas have in one respect been standardized, in that the Titan GOE will control, monitor, and target either re-entry vehicle, and conversely for the Atlas GOE. The re-entry vehicle is a special case where standardization in GOE is possible because its design is relatively independent of the vehicle which boosts it on the desired mission.

In existing ICBM's the GOE is designed to hold the missiles and facilities in a 15-min "readiness" condition. In the next generation of missiles we are striving for a much faster reaction time. This one criterion alone will cause the design of the missile and GOE to be considered as a system from the launch-control and monitoring console through each subsystem on the missile. Also, the very short reaction time makes it almost mandatory that the missile and GOE be highly reliable and that each be designed for rapid removing and replacing maintenance. In fact, the fast-reaction criterion will be felt all the way to the spare-parts supply bin. The GOE and missile system will be designed so that the only checks required other than those few accomplished during the countdown will be those necessary to determine which replaceable module in any subsystem has failed. Also, the fast-reaction-time criterion determines the reliability requirements of the ground-operating and missile-system equipment.

We are not now trying to achieve reliability by redundancy in the ground-system design except in one or two very critical areas. Reliability through redundancy is an area which cannot be treated in a general fashion but must be examined for each specific area of each design.

In summary, I have covered two of the three major types of ground equipment used in the ballistic-missile programs and the methods of identifying this equipment. These two types of equipment are Ground Operating Equipment and Ground Support Equipment.

The selection and identification of this equipment into the proper categories presents no problem if the definitions used here are applied. Examples of this are:

(a) For GOE, a functional analysis which shows the need for an azimuth-alignment system cannot be argued for the same reason that the need for an in-flight control system for the missile cannot be debated.

(b) In the identification of GSE, the functional analysis reveals maintenance and support requirements which are satisfied by missile trailers, test benches, test equipment, special tools, and calibration equipment. These maintenance and support requirements also include those generated by the GOE. In selecting these items, the need, quantity, and individual design is determined at least in part by the maintenance, operational, and logistic plans. Also, the missile and GOE designs are so interrelated that an optimum equipment distribution and division of functions between the missile and GOE are almost impossible unless they are designed as one complete system.

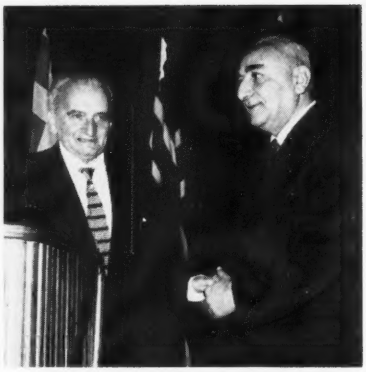
Applying these management procedures to programs as large as the ballistic-missile and space-vehicle programs enables both industry and the Air Force to achieve better systems with less over-all cost than by trying to manage everything on the ground as GSE. ♦♦

Hughes' Laser

The coiled light irradiates the ruby crystal above it, exciting an emission of "coherent" light. See Harold Lyon's article in the May *Astronautics* for a discussion of this "Laser."

(CONTINUED FROM PAGE 14)

gress for the past two years. The final decision on the site will be made by the IAF Bureau. Prof. Boneff, a Founding Member of the International Academy of Astronautics, is rightfully proud of Bulgarian astronautical efforts. He notes that members of the Bulgarian Astronautical Society have contributed original research papers on such subjects as meteoritic danger to space artifacts, the theory of relativity in astronautics, and determination of the mass of the earth by means of satellites, and that these papers are published on a regular basis. In addition, the Sofia Astronomical Observatory carries out optical, electronic and photographic observations of satellites and, in one publication alone (July 1960), fixed a total of 550 different satellite positions. Lecture series are constantly in progress and, during the past two years, astronautical expositions throughout the country have attracted an attendance of more than 300,000.



Theodore von Karman, left, is greeted by Gen. Cemal Gursel, Turkey's chief of state, prior to opening of 10th General Assembly of AGARD in Istanbul in October.

° ° °

Rep. Vicor L. Anfuso (D., N.Y.), Chairman of the Subcommittee on International Cooperation and Security of the House Science and Astronautics Committee, had a most productive visit to the Orient this summer, paralleling his European tour of the previous year. Before returning to this country he was the principal speaker and guest of honor at a special meeting of the Japanese Rocket Society and at the meeting was presented with an honorary life membership in the Society.

° ° °

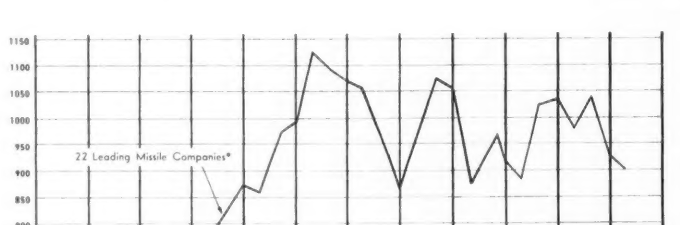
Theodore von Karman has carried the cause of astronautics to Turkey, despite changes in government and realignment of scientific and military personnel in that country. The 10th General Assembly of AGARD was scheduled for Istanbul long before the changes in government. Under the leadership of Gen. Cemal Gursel, the new chief of state of Turkey, the assembly was duly convened and an excellent meeting held. Dr. von Karman spoke on "Ballistics in the Past, Present and Future—From the Gun to Space Flight." A general panel discussion followed his presentation of the paper.

° ° °

P. K. Roy, director of the Legal Bureau of the International Civil Aviation Organization, and a member of the Council of the Astronautical Society of Canada was the guest speaker at an ASC meeting held October 19 in Montreal under the chairmanship of A. B. Rosevear, director of the Institute of Air and Space Law. His topic was "Some Recent Proposals Concerning Space Law."

Having just returned from the annual meeting of the International Law Assn. in Hamburg and the 11th IAF Congress in Stockholm, he was particularly well placed to give a true picture of recent trends in the development of space law. The gist of his address was that there are many subjects in that field upon which agreement could be reached now in anticipation of the space age of tomorrow. As he observed, the consensus is that outer space should be used only for peaceful purposes and, as declared by the jurists at Hamburg, outer space may not legally be subject to the sovereignty of any state, and celestial bodies should not be either. Undoubtedly certain rules of existing international law must apply to activities of nations in outer space, he noted, and others will not be beyond the capacity of lawyers to evolve. ♦♦

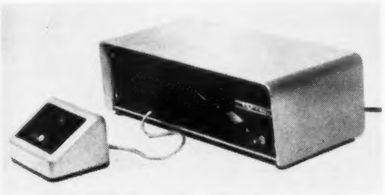
Missile market



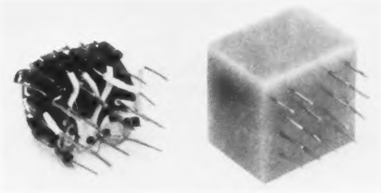
	Nov. 1960	Oct. 1960	% Change	Nov. 1959	% Change
Dow-Jones Industrials	580	580	±0	647	−10.4
Missile Index	900	936	−3.8	966	−6.9

NEW PRODUCTS CATALOGUE

EQUIPMENT . . . PROCESSES . . . MATERIALS . . . LITERATURE



Quality-Control Computer



Digital Modules

Memory Drum

Computers

Digitizing and Computing Unit. Voidicon Type V12-AD digitizer, memory unit, and control logic checks inner and outer contours of a large shell as it rotates on a precision table. **Adage Inc.,** Cambridge, Mass.

Comparator. Digital voltage comparator Model 465 indicates whether an applied voltage is over, between, or below present tolerance limits; range ±0.001 to ±1000 v. **Cohu Electronics,** Kin Tel Div., San Diego, Calif.

Quality-Control. Model 60-D Q-trol provides an electro-mechanization of the Wald theory of sequential analysis; features simplified formula setting mechanisms; interchangeable components of standard design. (Illustrated.) **Diversa Electronics Corp.,** Dallas, Tex.

Logic-Inverter Circuits. Provide logic inversion with level restoration; each of three units operates at frequencies up to 250 kc; power requirements ± 12 v DC; packed in EECO T-series containers. **Engineered Electronics Co.,** Santa Ana, Calif.

Information Processing. Computer automatically translates words and symbols into machine language; low-power requirements; handles large variety and quantity of peripheral devices. **GE Computer Dept.,** Phoenix, Ariz.

Digital Modules. Ten basic types and 15 variations of "building block" modules; proven circuit design; 35 standard components per cu in. or more than 50,000 components per cu ft; modules 0.8 in. high and 1 in. long. (Illustrated.) **GM Delco Radio Div.,** Kokomo, Ind.

Memory Drum. For airborne computers; length 3 in.; diam, 3 in; wt. 6 oz; holds 100,000 bits of information; drum assembly weighs 8 lb; withstands force of 15 g. (Illustrated.) **IBM Federal Systems Div.,** Oswego, N.Y.

Digital Comparator. Compares measurement numbers at rates as high as 100,000 per sec, using solid-state circuitry; power requirements of 1 amp at 15-v DC. **Leach Corp.,** Compton, Calif.

Ultrafast. PB 250 combines large expandable memory and versatile command structure with computing speed in microsecond range; serial, binary, single-address computer with internally stored program. **Packard Bell Electronics,** Los Angeles, Calif.

Additional information about any of the products, equipment, processes, materials and literature listed on these pages may be obtained by writing to the New Products Department, ASTRONAUTICS, 500 Fifth Avenue, New York 36, N. Y.

Univac STEP. Solid-state computer system for Simple Transition to Electronic Processing; can be expanded by adding up to four additional memory units each carrying 6000 more digits. **Sperry Rand Corp.,** Remington Rand Univac Div., New York, N.Y.

Connectors

Adjustable Bolts. Tightening of nut adjusts diameter; eliminates reaming, taper pins and close-tolerance reaming; uses nominal bolt diameters and lengths. **Adjustable Bushing Co.,** N. Hollywood, Calif.

Quick-Release Bolt. Engaged or disengaged by releasing or depressing button operating a spring-loaded mandrel; alloy or stainless steel, in 5/16, 3/8, and 1/2-in. sizes. **Avdel, Inc.,** Burbank, Calif.

Coupling. Ultra-high vacuum; sizes for 1/8-through 5/8-in.-OD tube; no leaks measurable on a helium mass spectrometer with sensitivity of 1.7×10^{-10} atmos cc/sec/division. **Cajon Machine Co.,** Cleveland, Ohio.

Gold-Bonded Contacts. Standard button or rivet size and shape and new ball-contact shape; replaces platinum, gold and palladium. **Contacts, Inc.,** Wethersfield, Conn.

Terminal Strip. Quick disconnect; a combination of conventional-design barrier terminal strip and a blade-type interconnecting strip; speeds maintenance of electronic systems. **Infrared Industries, Inc.,** Waltham, Mass.

Micro-Miniature. Multicontact power, coaxial, and combination connectors; line includes over 250 different units approximately 1/3 the size of previous units. **Microdot, Inc.,** S. Pasadena, Calif.

Quick-Coupling. Double shutoff; handles gases and industrial fluids; two-way check valve stops flow from both lines with minimum fluid loss; steel or brass. **Perfecting Service Co.,** Charlotte, N.C.

Miniature Couplings. Instrument-type flexible shaft; two types; no backlash; accommodate lateral and angular misalignment; light weight. (Illustrated.) **Technology Instrument Corp.,** Needham, Mass.

Slip Clutches. Friction-type adjustable over wide torque range without removal from system; protect components against excessive or inertia shock loads. **Technology Instrument Corp.,** Needham, Mass.

Precision Drives. Dual speed; choice of three types and precision-worm-gear drive; operate with rotary components such as resolvers, synchros, timing coils, etc. **Technology Instrument Corp.,** Needham, Mass.

Cooling Systems

Blower. Long-life 2-in. blower has removable motor unit to facilitate field servicing; 400 cycle; stainless steel; AC and DC; 22,000 rpm. **Benson Mfg. Co.,** Dean & Benson Research Div., Kansas City, Mo.

Airborne Unit. Provides Coolanol 45 at max temp of 185 F at 1 gpm and 55-psig system-discharge pressure; power requirements 115/208 v, 400 cycles, 3 phase and 28-v DC for control. **Eastern Industries, Inc.,** Hamden, Conn.

Constant-Mass Fan. Motor and fan coupled by constant-torque magnetic device; fan speed varied directly with altitude or inversely with square root with relative density of air being handled. **Eastern Industries, Inc.,** Hamden, Conn.

Peltier Cooling Unit. Dissipates 65.3 watts of heat to ambient air at 140 F at sea level; temperatures maintained below 110 F; heat pump uses 64 thermoelectric couples formed into a cooling plate. (Illustrated.) **Garrett Corp.,** AiResearch Mfg. Div., Los Angeles, Calif.

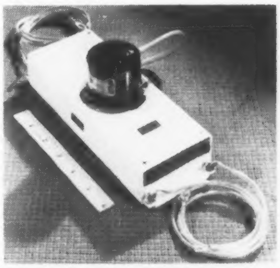
Pump System. Uses centrifugal pump to circulate fluid through a heat exchanger, then through the electronic gear; 2 lb per dissipated kw; fluid rates as high as 52 gpm; output pressure, 100 psi. (Illustrated.) **Sperry Rand Corp.,** Vickers Inc. Div., Detroit, Mich.

Motors

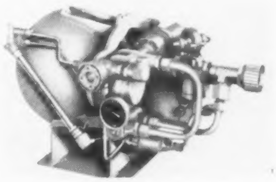
Variable-Ratio Transmission. For use in machine tools; need not be limited to relatively few operating speeds; also useful in driving pumps in chemical processing; efficiency, 90 per cent. **Avco Lycoming Div.,** Stratford, Conn.

Midget Missile-Motor. Hydraulic motor for controlling missile antennas; develops 1/3 hp at 6000-rpm continuous speed; less than 1 cu in.; wt, 4 oz. **Bendix Hamilton Div.,** Hamilton, Ohio. ♦♦

Miniature Couplings



Peltier Cooling Unit



Pump Cooling System

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